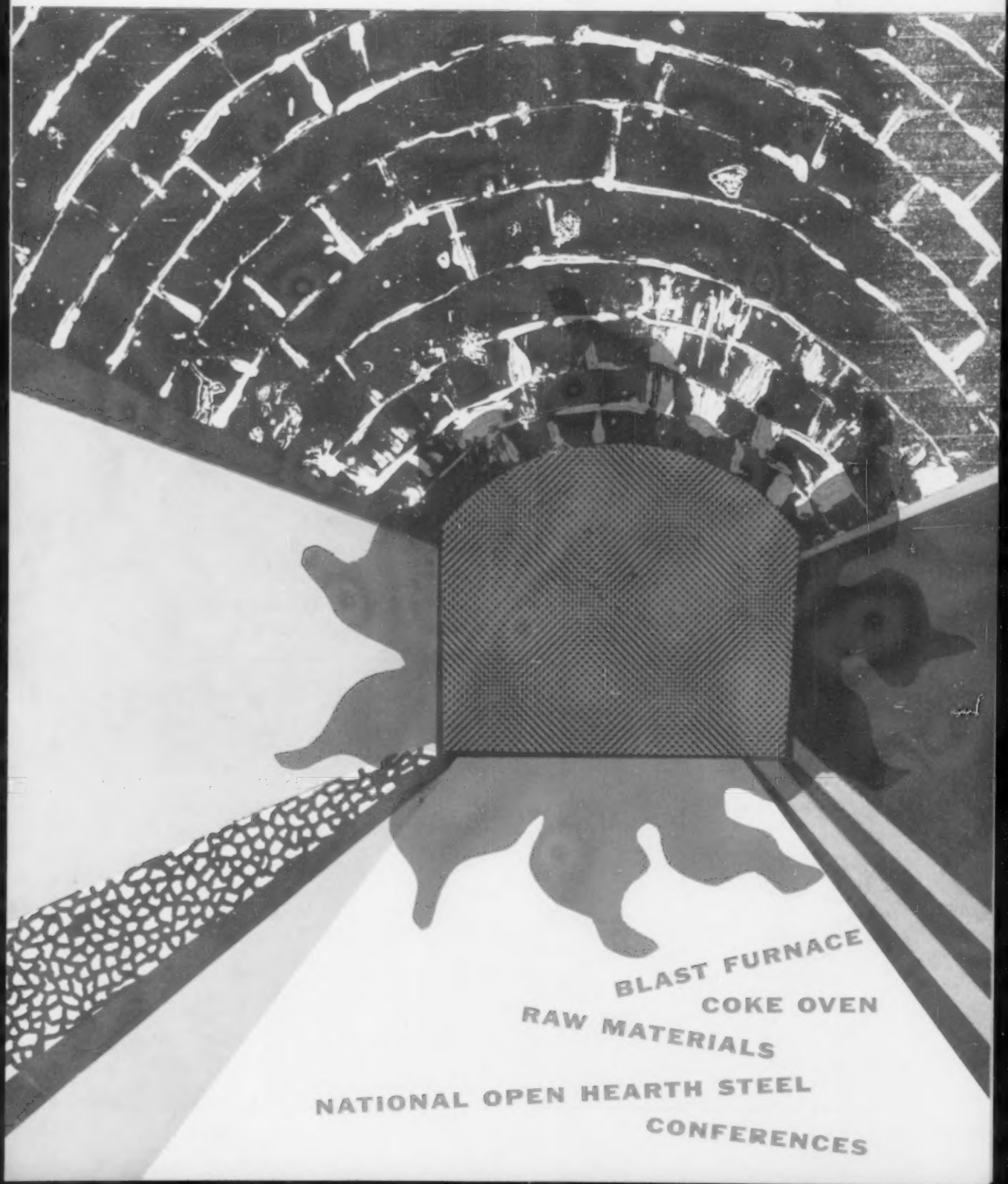
JOURNAL OF

METALS

APRIL 1958



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JOURNAL OF

METALS

VOL. 10, NO. 4 APRIL 1958

Published to provide a continuing, authoritative, and up-to-date record of technological, engineering, and economic progress in all branches of the industry by The Metallurgical Society, American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., 29 West 39th Street, New York 18, N. Y.

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COVER

The intense heat of the open hearth furnace caught the imagination of Cover Designer Naomi Lazard; and consequently, this month's cover gives the view a piece of cold scrap might have upon being charged. In this issue, the Editors have brought together articles of broad interest to all iron and steel men.

FEATURES

Personnel	214	Education News	300
Books	230	Around the Sections	302
Reporter	241	Personals	304
Editorial	260	Coming Events	310
AIME News	297	Advertisers Index	310

R. W. Shearman Reports on The Metallurgical Society 1957-1958 p. 260

W. R. Hibbard, Jr.: Biography of The Metallurgical Society's New President p. 296

41ST IRON AND STEEL CONFERENCE

Blast Furnace, Coke Oven, and Raw Materials Committee 242

National Open Hearth Steel Committee 243

National Open Hearth Steel Program 247

Blast Furnace, Coke Oven, and Raw Materials Program 249

National Open Hearth Steel—Local Section Activities 252

IRON AND STEEL ARTICLES

New Developments in Steelmaking Processes — D. L. McBride — 263

Humidified Blast Furnace Operation — R. J. Wilson — 268

Firing Practice: Natural Gas Replaces Steam
Granite City Steel Co. — J. E. Goodin — 272
Empire-Reeves Steel Corp. — V. B. Thompson — 273

Iron-Coke Process — H. Barking and C. Eymann — 274

Expansion Allowance in Basic Open Hearth Port Ends — L. L. Wells and T. P. Greaney — 277

New Drawing Process Eliminates Heat Treating for Strong Parts — E. S. Nachtman and E. B. Moore — 281

A Radioactive Tracer Study of Steel Surface Defects — T. W. Crosta — 285

Carbon Monoxide Reduction of Iron Ore — Otto Stelling — 290

1957 Index Follows Page 310

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(Continued on page 216)

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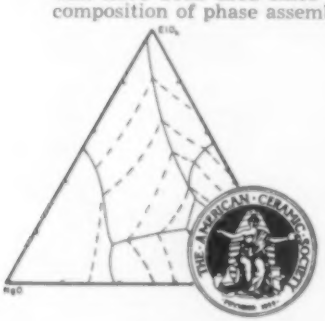

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Additional classified advertising appears on page 216.

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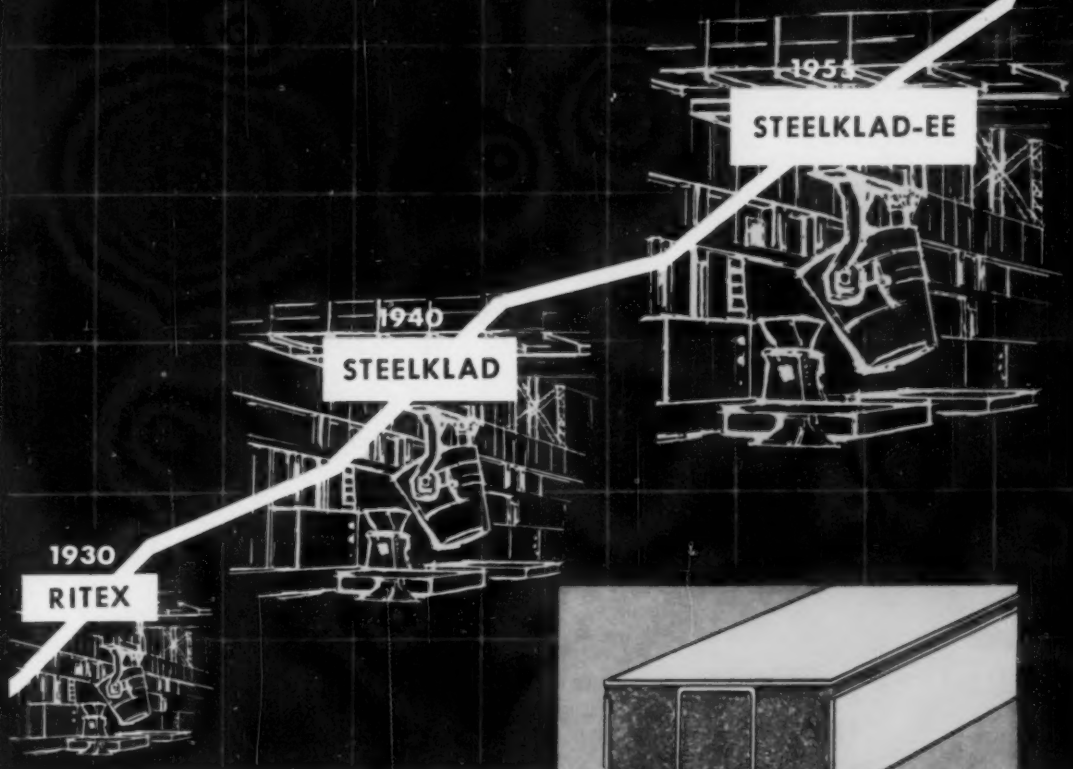

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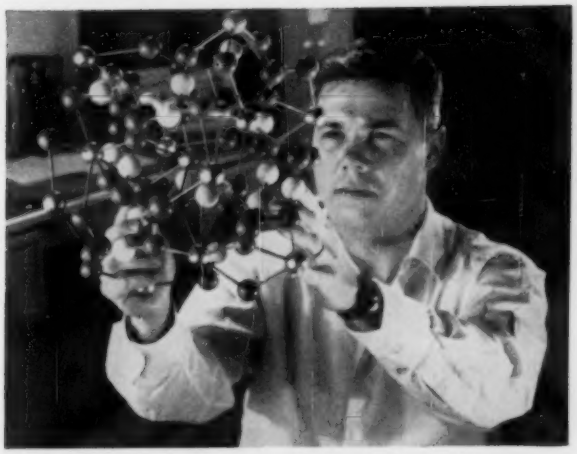

Dr. Walter Brown, physics graduate of Duke and Harvard Universities, bombards crystalline solids with one-million-volt electrons to study the nature of simple defects in crystals. Objective: new knowledge which may help improve transistors and other solid state devices for new and better telephone and military systems.

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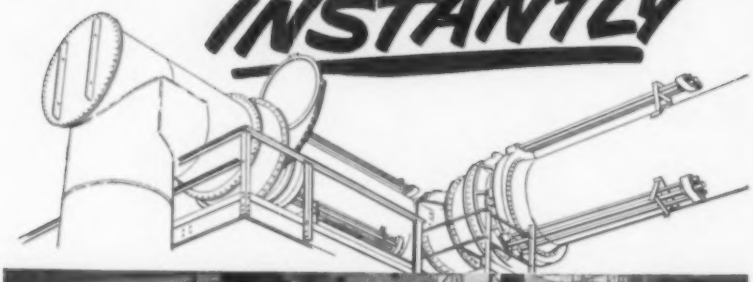

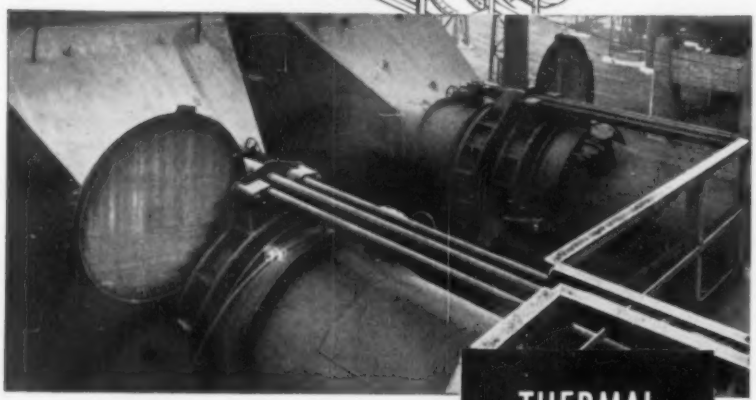

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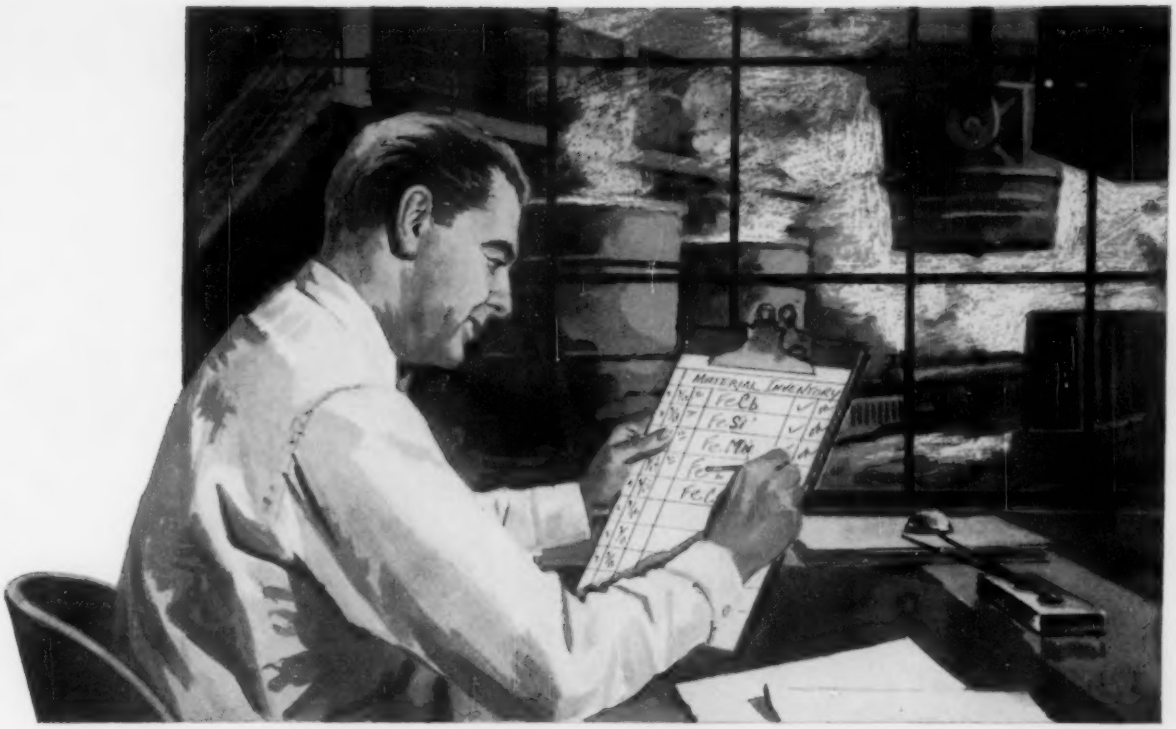

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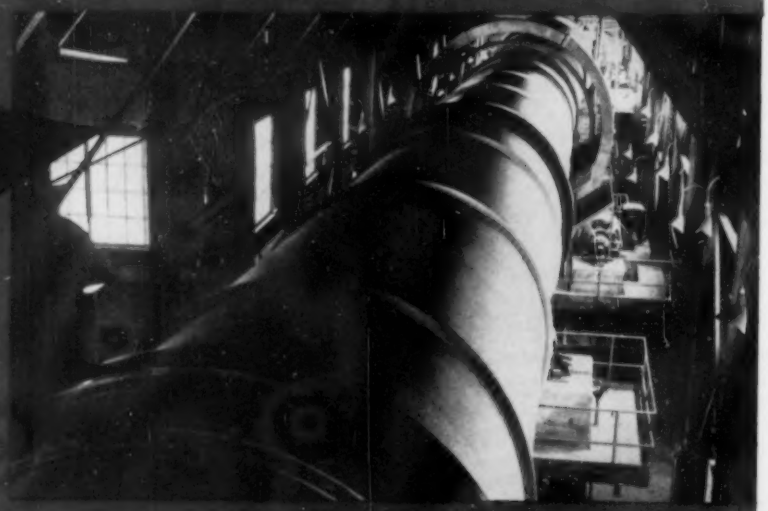

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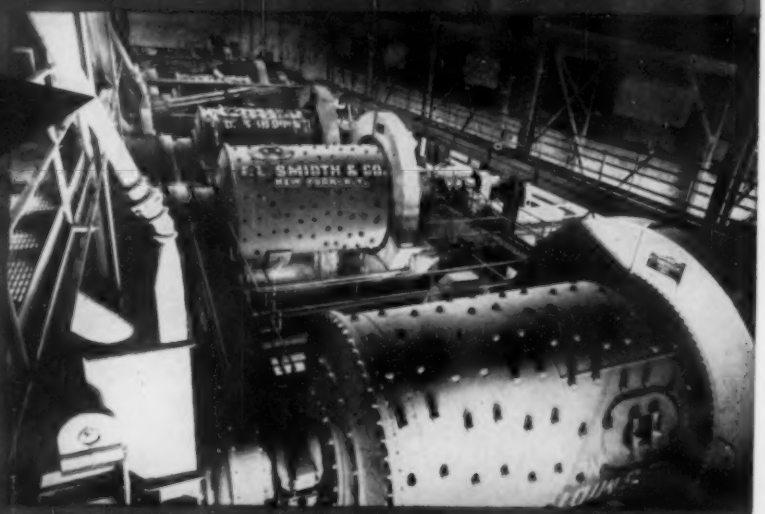

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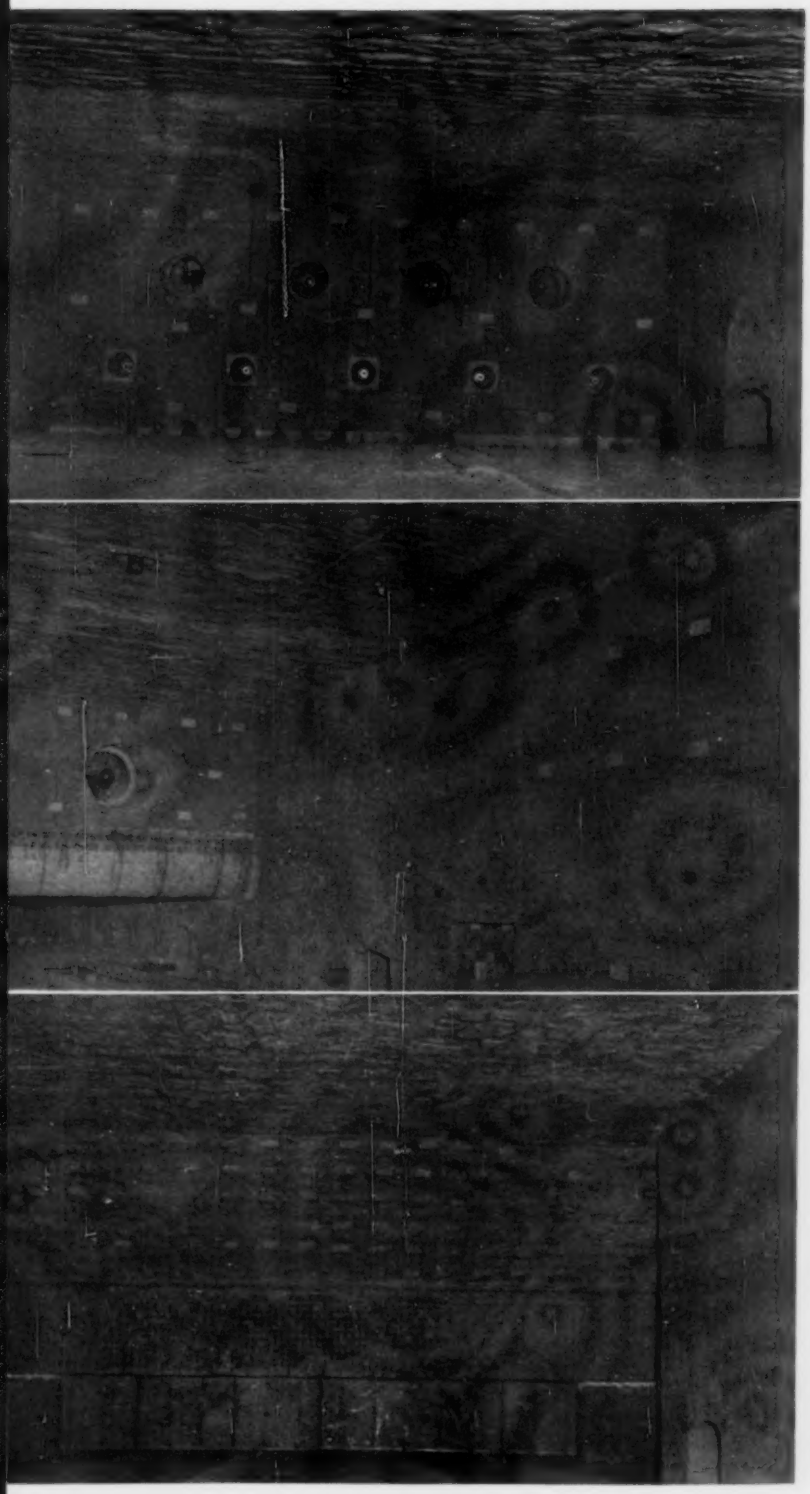

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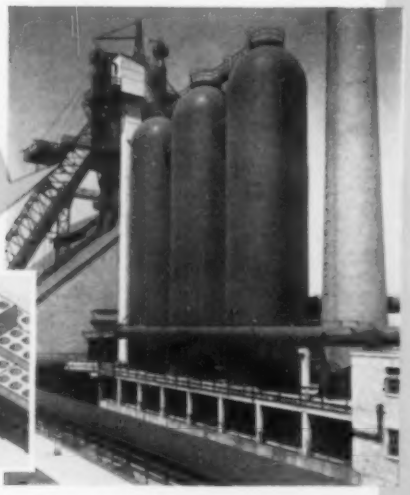

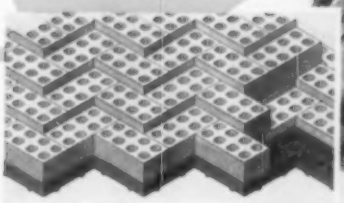

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STOVE DATA

Typical stove sizes (Dia. and hgt.)	**22′ 0″ x 100′ 0″**	**28′ x 123′ 6″**
Total heating surface, sq. ft.	**147,000**	**321,267**
Heating surface in MOHR checkers* sq. ft.	**142,000**	**313,926**
Free area combustion chamber, sq. ft.	**31.1**	**62.7**
Free area MOHR checkers, sq. ft	**77.6**	**139.7**
Weight of MOHR checkers, lbs.	**1,400,000**	**3,108,000**

***All heating surface is vertical.**

OPERATING DATA

Typical flue temperature **350°–400°F**

Efficiency **85–88%**

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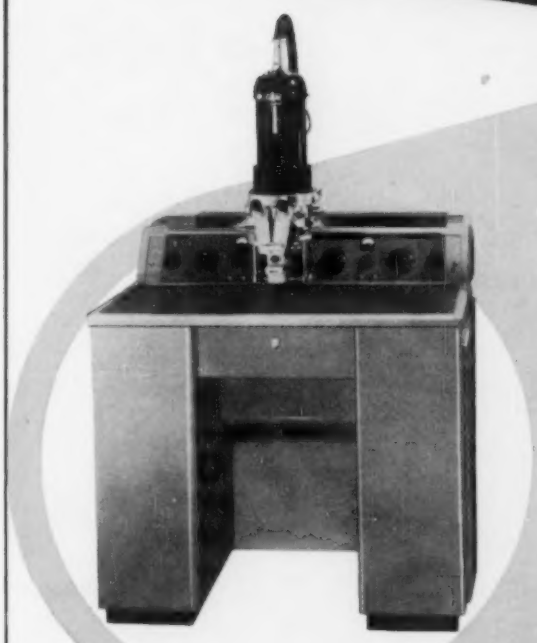

This new apparatus provides a safe, practical means by which critical evaluations of opaque specimens may be made. The PMR X-ray Microscope is an important adjunct to both optical and electron microscopes. Both industry and laboratories dealing with biologicals, pharmaceuticals, agriculture products, minerals, metals, rubber and plastics, as well as forensic problems will find X-ray microscope analyses of inestimable value.

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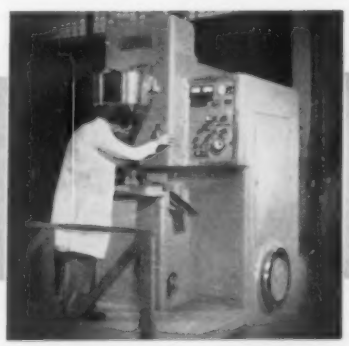
Donald O. Buker, Assistant Project Engineer, checks on an experimental melt in progress in the Stokes Vacuum Furnace. External controls and alloying devices afford complete access and manipulation of the melt.

THE METALS INDUSTRY IS PROFITING FROM THE USE OF OTHER STOKES PRODUCTION EQUIPMENT



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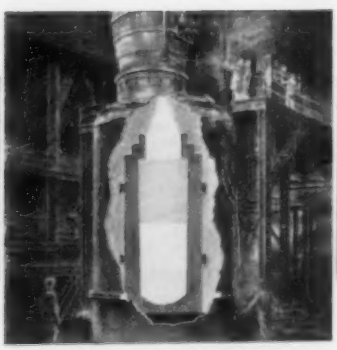

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Vanadium Corporation of America keeps Stokes Vacuum Furnace busy in Ferroalloy Research

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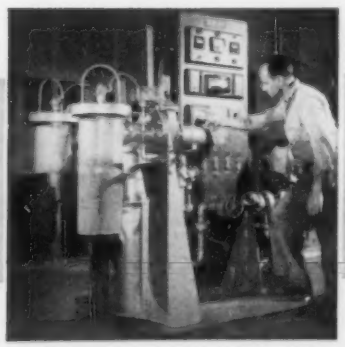

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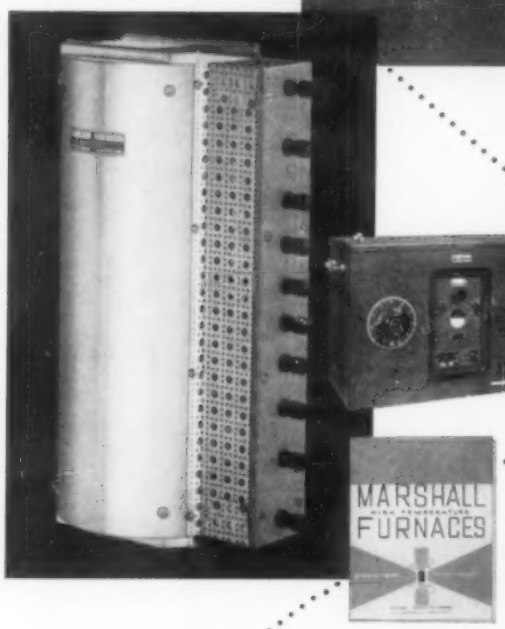

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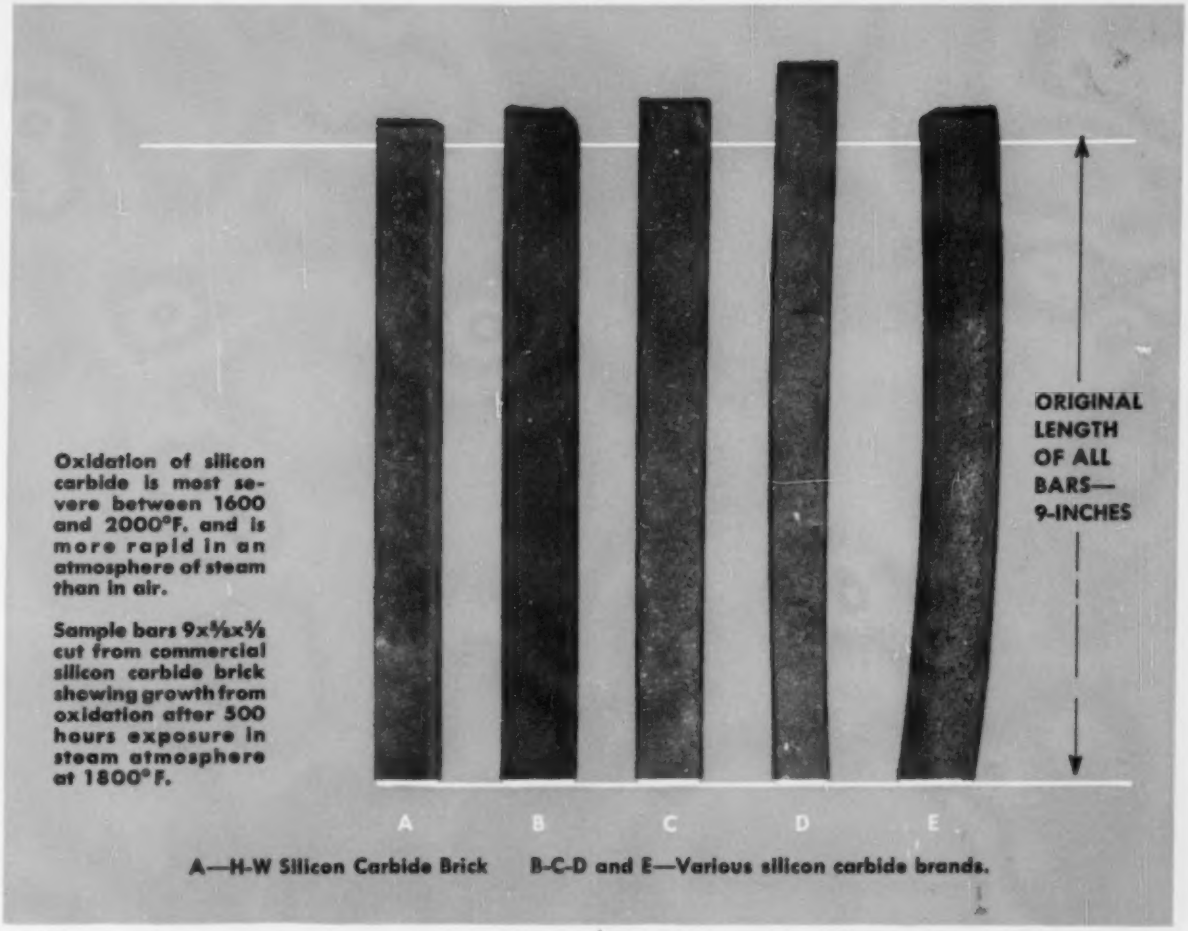

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Dislocations and Mechanical Properties of Crystals, by Fisher, Johnston, Thomson and Vreeland, Editors, *John Wiley & Sons Inc.*, 634 pp., $15.00, 1957.—This book presents in a very complete manner, the principal methods for observing individual dislocations of crystals as well as mechanical properties. It reviews the parts of the field which are most complicated and least understood, so that the present state of the subject is made quite clear. Fifty-four of the world's leading authorities in the field have contributed to make it a complete and up-to-date account. The work grew out of a small international conference held at Lake Placid, New York, Sept. 6-8, 1956. The conference was sponsored by the Air Force Office of Scientific Research, Air Research and Development Command, and The General Electric Research Laboratory. •

Soviet Education For Science And Technology, by Alexander G. Korol, *John Wiley & Sons Inc.*, 513 pp., $8.50, 1957.—A general outline of the educational system of the Soviet Union from elementary through graduate school. A considerable portion of the book is devoted to the technicum and other specialized schools which train students for work at the subprofessional level. The book includes an extensive study of Soviet undergraduate higher education, with curricula in physics and a typical major in mechanical engineering shown in detail. The author's conclusions are at variance with some of the accepted generalizations concerning Soviet education. •

Grain Boundaries in Metals, by D. McLean, *Oxford University Press*, 144 Fifth Ave., New York 11, N. Y., 346 pp., $8.00, 1957.—A study of grain boundaries in metals that attempts to correlate and classify the

basic problems involved. It includes a great deal of numerical data useful in approaching the subject. Starting with theories about the structure of grain boundaries and their influence on microstructure, diffusion, fracture, and behavior during plastic deformation, the book then continues with energies of grain boundaries, migration of boundaries, and special features of low angle boundaries.

Gmelin: **Handbuch der Anorganischen Chemie,** System 28 (calcium) part B2, compounds of calcium, up to dithionit, xvi, *Walter J. Johnson Inc.*, 111 Fifth Ave., New York 3, N. Y., 392 pp., 46 illustrations, Unbound, $52.00, 1957.

Atomic Power, An Appraisal, *Pergamon Press,* 122 E. 55th St., New York 22, N. Y., 151 pp., $3.50, 1957.—The contents of this volume are based on an informal panel discussion held by the International Bank for Reconstruction and Development. The participants, all leading world figures in atomic energy development, present a picture of the present and future potentialities of nuclear power in economic terms and its probable impact upon individuals and nations. To provide an introductory frame work, the volume begins with a series of chapters devoted to the atom, atomic energy, radioisotopes, and related subjects.

Canadian Resources, Part I, *Stanford Research Institute,* Menlo Park, Calif. (Copies may be obtained from the Editor, Western Resources Handbook, at the Institute Address) $10.00, 1958.—This book is a volume of selected statistics relating to natural resources, and the industrial and commercial development of Alberta, British Columbia, Manitoba and Saskatchewan. One-hundred twenty-five data sheets give detailed information on each province's climate, general economic indicators, population, employment, income, agriculture, energy, manufacturing, construction and transportation. The material is presented in tabular form supplemented by graphs, charts, and maps. Information was collected principally from the Dominion Bureau of Statistics and other Canadian government agencies. The volume will be supplemented at a later date by information on other areas of Canada.

Aluminum Soldering, Information Bulletin 23, *The Aluminium Development Association,* 33 Grosvenor St., London, W.1, England, 35 pp., 28¢, 1957.—This Bulletin is the latest in the Association's series on the methods of joining aluminium and its alloys: There are three information bulletins on welding, one on brazing, and one on riveting. The principal section of the book deals with soldering methods and equipment. Covered are: preparation for soldering, heating for soldering, and soldering techniques. Other information discussed in the book are: basic principals of soldering aluminium, aluminium and its alloys suitable for soldering, solders, fluxes, finishing soldered components, soldering aluminium to other metals, properties and characteristics of soldered joints, and choice of solder and soldering methods. The bulletin is complete with three appendices and a selected bibliography.

Metallurgical Aspects of the Control of Quality in Non-Ferrous Castings, Inst. on Metals Monograph and Report Series No. 22, *The Institute of Metals,* 17 Belgrave Square, London, S.W. 1, England, 148 pp., $5.50, 1957.—This Monograph contains papers from a symposium held in London, England on the occasion of the Annual General Meeting of the Institute, May 1, 1957. Some of the papers discussed are: the metallurgical principals of the control of quality of non-ferrous castings, the role of statistical methods in controlling the quality of non-ferrous castings, metallurgical control of quality in the production of aluminium alloy castings, the control of quality of magnesium-base alloy castings, the control of quality of pressure die castings, and non-destructive testing in the control of quality of non-ferrous castings. The monograph is illustrated with tables and contains twenty plates.

(Continued on page 234)

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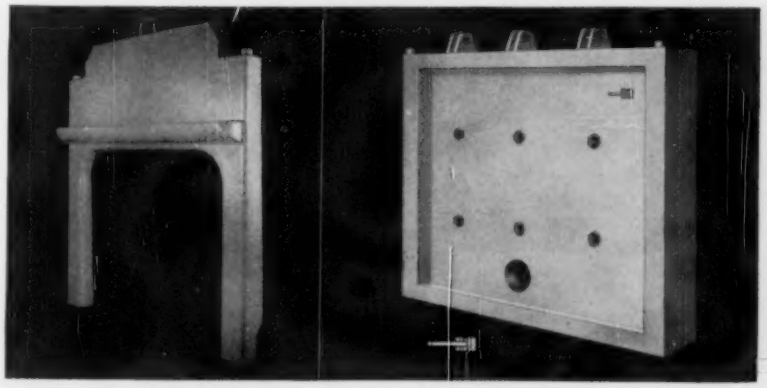

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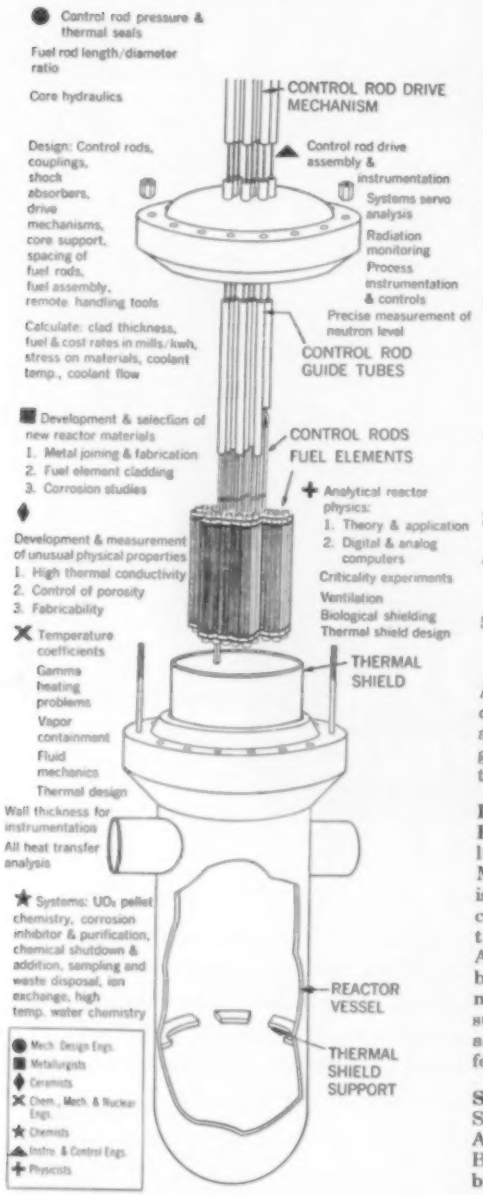
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This diagram shows the main parts of a pressurized water atomic power reactor, one of many types being designed at Westinghouse Atomic Power Department . . . and just what work would be done by you in the commercial atomic power industry. There are many overall studies on which you may work, as well as specific studies.

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FIRST IN ATOMIC POWER

Books

(Continued from page 231)

FBI Register of British Manufacturers—1958, 30th Edition, published for the Federation of British Industries by *Kelly's Directories Ltd.* and *Iliffe & Sons Ltd.*, Dorset House, Stamford St., London S.E. 1, England, 1138 pp., $5.94, 1957.—This comprehensive and accurate guide to a substantial cross section of British industry lists the products and services of over 7500 member firms under more than 5400 alphabetical headings. In addition to the classified buyers' guide, there are seven other sections in the Register, giving addresses of companies and firms, and valuable information about trade associations, property names, trade marks, etc. A feature providing a useful reference for buyers not fully conversant with British product terms, is the French, German and Spanish glossaries. These give translations of every product term used in the main buyers' guide, each being numbered for easy reference between the headings and their translations. The register is the only authorized directory of the Federation of British Industries, the largest and most influential association of British manufacturers.

Difficulties Encountered In Smelting In The Lead Blast Furnace, by R. W. Ruddle, *The Institution of Mining and Metallurgy*, 44 Portland Place, London, W.1., England, 56 pp., $1.06, 1957.—This booklet is largely a critical survey of the work of Oldright and Miller contained in 16 reports of the U. S. Bureau of Mines published between 1929 and 1934, and the aim has been to make more accessible the details of these reports and discuss them in the light of latter experience. The review is in three main parts: the first contains basic information on the blast-furnace operating conditions at Tooele, Kellogg and Trail smelters; the second is devoted to the formation of accretions at these smelters; and the third deals with the factors governing the lead contents of the slags. Included are general discussions on accretions and lead losses, and suggestions for lines of research concerning these aspects of lead smelting.

Materials Handling Equipment, by D. Oliphant Haynes, Chilton Book Div., *Chilton Publications*, 56th & Chestnut Sts., Philadelphia 39, Pa., 636 pp., $17.50, 1957.—Here in one well organized volume is the complete story of machines and systems, what they do and how they do it. Made graphic by over 2200 illustrations, the text fills a long felt need in both industry and colleges. Covered in the book are such topics as

(Continued on page 238)

A MEMORIAL VOLUME TO C. H. HERTY, JR.

DEOXIDATION OF STEEL

TABLE OF CONTENTS

		Page
Preface		
Frontispiece		
Charles Holmes Herty, Jr. Biographic Sketch		1
Et Al		iv
List of Publications		viii
Acknowledgment		xiii
Chapter I.	The Significance of Herty's Work to Modern Steel Practice by G. R. Fitterer	xv
Chapter II.	Elimination of Metalloids in the Basic Open Hearth Process by J. L. Keats and C. H. Herty, Jr., Trans. AIME, Vol. 73, 1079-1106, 1926	41
Chapter III.	The Solubility of Iron Oxide in Iron by C. H. Herty, Jr., J. M. Gaines, Jr., B. M. Larsen, W. A. Simkins, R. L. (Geruso) Humphrey and S. P. Watkins, Cooperative Bulletin No. 34, Metallurgical Advisory Board*, 68 pages, 1927	71
Chapter IV.	A New Method for Determining Iron Oxide in Liquid Steel by C. H. Herty, Jr., J. M. Gaines, Jr., Hyman Freeman and M. W. Lightner, Trans. AIME, Iron and Steel Division, Tech. Paper 311, 28-38, 1930	143
Chapter V.	Deoxidation with Silicon and the Formation of Ferrous-Silicate Inclusions in Steel by C. H. Herty, Jr., and G. R. Fitterer, Cooperative Bulletin No. 56, Metallurgical Advisory Board, 94 pages, 1928	157
Chapter VI.	Deoxidation with Silicon in the Basic Open Hearth Process by C. H. Herty, Jr., C. F. Christopher and R. W. Stewart, Cooperative Bulletin No. 58, Metallurgical Advisory Board, 172 pages, 1930	255
Chapter VII.	Deoxidation of Steel with Aluminum by C. H. Herty, Jr., G. R. Fitterer and J. M. Byrns, Cooperative Bulletin No. 46, Metallurgical Advisory Board, 45 pages, 1930	429
Chapter VIII.	Deoxidation of Open Hearth Steel with Manganese-Silicon Alloys by C. H. Herty, Jr., C. F. Christopher, M. W. Lightner and Hyman Freeman, Cooperative Bulletin No. 58, Metallurgical Advisory Board, 71 pages, 1932	477
Chapter IX.	The Control of Oxide in the Basic Open Hearth Process by C. F. Christopher, Hyman Freeman and C. H. Herty, Jr., Cooperative Bulletin No. 68, Metallurgical Advisory Board, 128 pages, 1934	553
Chapter X.	The Effect of Deoxidation on the Impact Strength of Carbon Steels at Low Temperatures by C. H. Herty, Jr. and D. L. McBride, Cooperative Bulletin No. 67, Metallurgical Advisory Board, 60 pages, 1934	659

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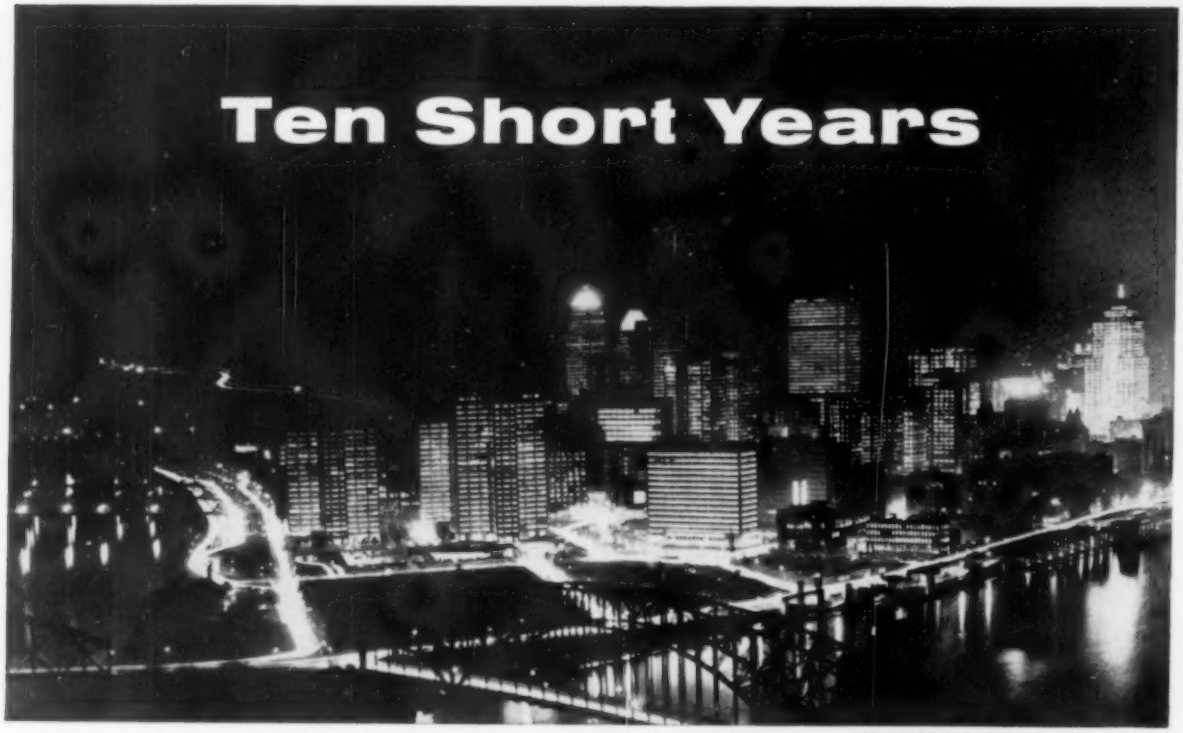

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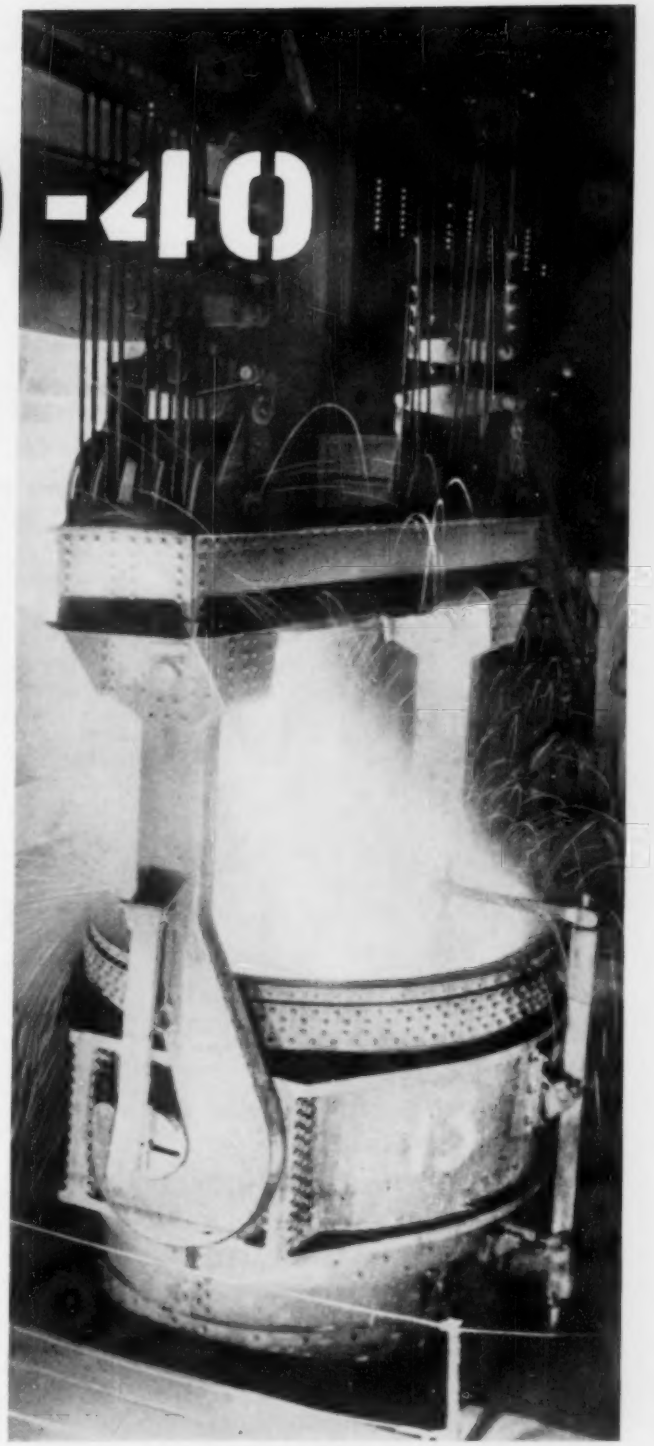

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Books

(Continued from page 234)

basic types of equipment and their capabilities, unit-load handling, in-process handling, integration of production machinery with handling equipment, package handling, techniques for analyzing specific problems, cost analysis, and organization and control of handling systems.

Smoley's Tables—*C. K. Smoley & Sons Inc.*, P.O. Box 14, Chautauqua, New York.—These mathematical handbooks are recognized as a standard tool of the American drafting room. The series of handbooks includes **Parallel Tables of Logarithms and Squares**, $6.00; **Handbook of Logarithmic-Trigonometric Tables**, $1.50; **Parallel Tables of Slopes and Rises**, $6.00; **Segmental Functions**, $5.00; **Four Combined Tables** (the above four books in a single volume), especially edited and expanded with over 350 pp. of new material, $12.00; and three combined tables (the first three books listed above) $10.00.

Proceedings of the Thirteenth Annual Meeting (1957) of the Metal Powder Assoc. Two volumes, *Metal Powder Assoc.*, 130 W. 42nd St., New York 36, N. Y., 1957.—Vol. I, **General Session on Powder Metallurgy**, $4.00. —This volume covers all phases of the industry, including production techniques, new machinery, and novel applications for powder metals. Complete transcriptions of all individual papers, symposia and panel discussions are included. Of special interest is the panel discussion on presses for compacting metal powders. This panel brings together for the first time representatives of all the major producers of both American and European metal powder presses.

Volume II, **Ferrites and Electronic Core Session**, $3.00.—This volume is devoted to special problems of ferrites and electronic cores. The important field of miniaturization in electronics is the subject of a comprehensive paper on improved ferrite and iron powder cores in both military and commercial equipment. Of equal significance is another paper detailing the characteristics and applications of powerful, non-magnetic ceramic permanent magnets. Each volume is available individually.

Hot Laboratory Operation and Equipment, third and final volume of Proceedings of the 1957 Nuclear Engineering and Science Conference, *American Soc. of Mechanical Engineers*, 29 W. 39th St., New York 18, N. Y., $17.50, 1958.—This book contains the papers delivered at the fifth Hot Laboratories and Equipment Conference, which was held as part of the Nuclear Congress. Some 60-odd papers, and a considerable amount of material added by the authors after presentation of the papers are included. They cover the range of equipment for hot chemical, physical, mechanical and metallurgical operations, hot cell installations, hot laboratory facilities, operation and administration, and specialized applications. All the original photos and diagrams are included.

The complementary books of the series, **Advances in Nuclear Engineering**, deals with the complete fuel cycle, from the availability of natural resources to the radioactive recyclès and waste disposal. The three volumes together are $45.00. The books are $17.50 separately.

Van Nostrand's Scientific Encyclopedia, Third Edition, *D. Van Nostrand Co. Inc.*, 120 Alexander St., Princeton, N.J., 1839 pp., $30.00, 1958 —Considerably revised, this comprehensive reference work presents some 15,000 separate topics dealing with principles and applications of the physical sciences, medicine, and technology, including nuclear science and engineering. The presentation of each topic, beginning with a simple nontechnical definition and progressing to the more advanced phases, is helpful to the general reader. In addition to the customary cross-references, all terms in the main alphabetical list are printed in heavy type wherever they occur.

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Unique electrode feed. The high quality of the melts is attained by feeding the consumable* electrodes at optimum rates. An electronic system, the Heratron Control, monitors arc voltage, current, and short circuits—and automatically maintains the arc between ½ and 1 inch in length.

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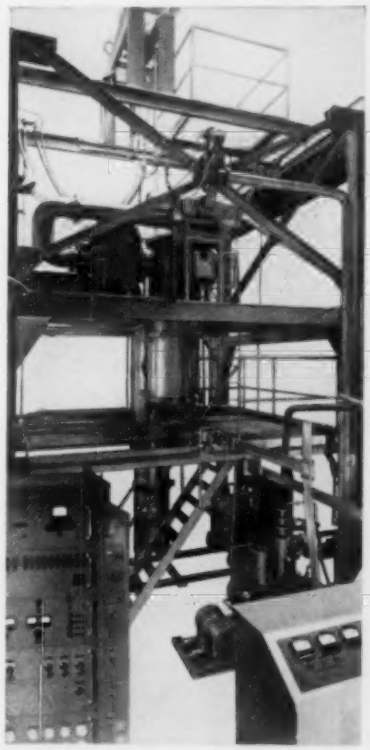
How to purchase. There are five standard models of the Heraeus furnace with capacities from 20 lbs. to 6600 lbs. of steel—and special designs with capacities ranging up to and beyond 10,000 lbs. of steel.

CEC has an exclusive license to sell and service these furnaces, the Roots pumps, and accessories. For a complete discussion of these proved furnaces, write for Bulletin 4-27.

*The smallest of these furnaces also operate with nonconsumable electrodes

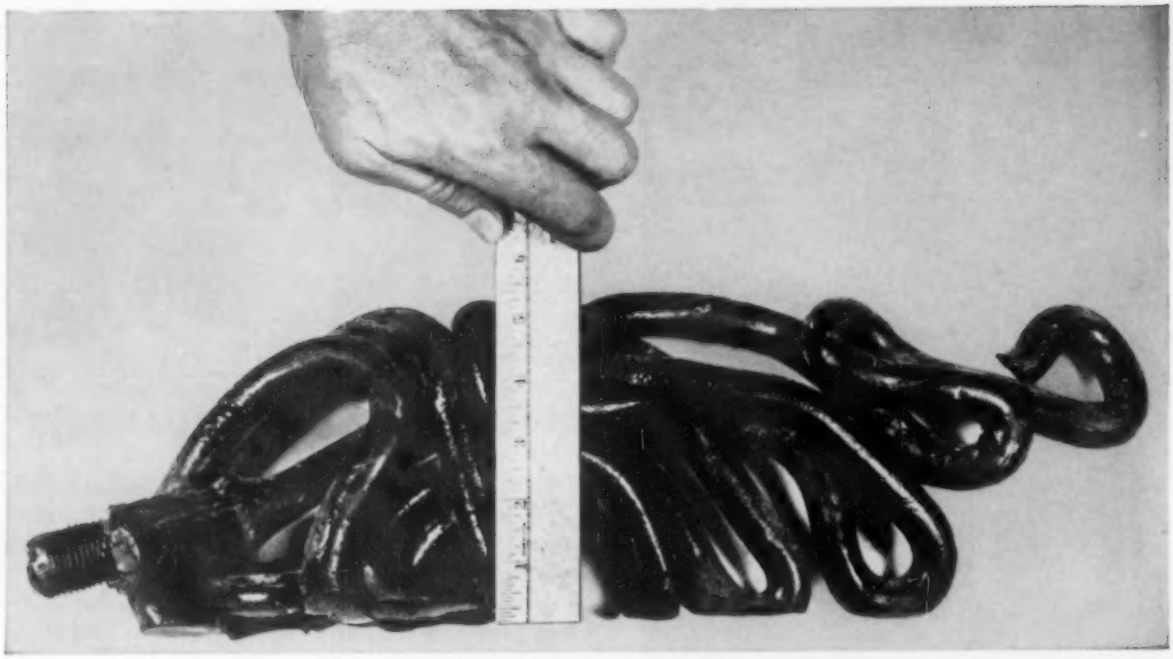


Ingots of 16″ diameter can be processed in this Model VA-L 600 sh Heraeus furnace.

Consolidated Electrodynamics

Rochester Division, Rochester 3, N. Y.

SALES AND SERVICE OFFICES IN PRINCIPAL CITIES



This steel "pretzel" was 14 feet long!

Down near Caprock, New Mexico, they're still talking about it . . . the nickel alloy steel sucker rod that squashed into 18 inches.

It took an accident to demonstrate real toughness.

The sucker rod, a long shaft connecting power at the surface with a piston thousands of feet below, was operating rhythmically. Its reciprocal motion brought up oil in rich spurts.

Suddenly, part way down, the well casing broke, trapping the sucker rod. Fourteen feet of rod were quickly crammed into 18 inches. But despite violent twists the sucker rod *didn't break!* See for yourself!

Nickel alloy steel provides toughness... plus fatigue resistance

Stresses on sucker rods from the pumping motion are high, and fatigue life must be extended as far as possible even in corrosive wells. That's why this one was made of AISI 4820 steel – a high-strength nickel alloy steel containing 3.5% nickel and .25% molybdenum.

It's a quenched and tempered steel. Normally a carburizing grade, 4820 specially quenched and tempered gives excellent toughness along with through hardness and relatively high strength.

Typical mechanical properties are:

Ultimate strength	120,000 psi
Yield strength	110,000 psi
Elongation	25% in 4 x diam.
Reduction of area	68%
Brinell hardness	241
Izod impact	90 ft. lbs.

We don't know of many better illustrations of the toughness and ductility of high strength nickel alloy steels than this one.

At any rate, down near Caprock, New Mexico, they're still talking about it.

If you'd like to know more about high mechanical properties of Nickel Alloys Steels . . . their strength, toughness, ductility and resistance to corrosion fatigue, for example, send for "The Properties of Heat Treated Wrought Nickel Alloy Steels."

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Steel Production Abroad:

Output Holds, Except in Heavy Exporting Countries

The **French** steel picture is optomistic, with March production expected to match the record level of January. In the **UK**, February's steel production was down only slightly from the same month of 1957, while in **Italy** it was up slightly.

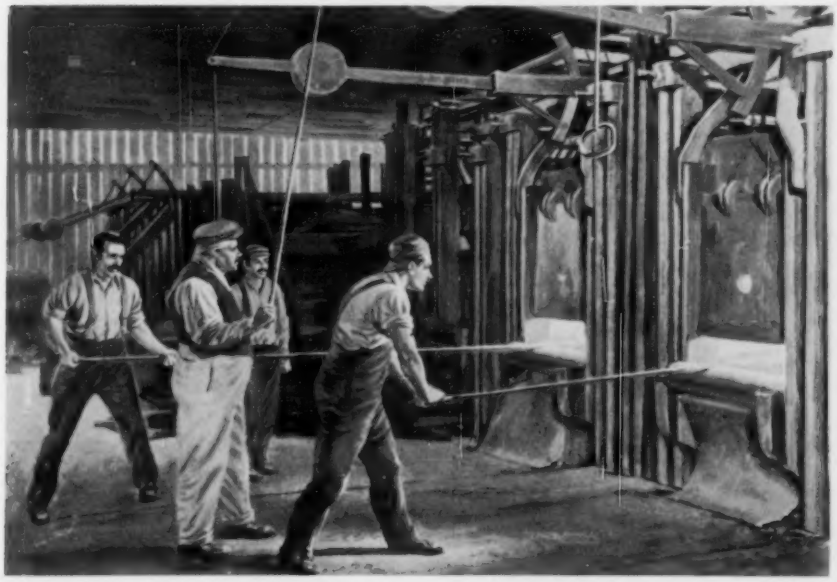
In **Germany**, February 1958 steel output was above 1957, but the backlog of orders in only 3½ months, compared with 6 months one year ago. Thus, in March two of the largest German steel firms have announced production cuts of 10 pct or more. Ruhr coal stocks are reported to be growing at a rate of 50,000 tons per day.

Belgium's export-oriented steel industry is more affected, and February's output fell to 490,000 metric tons compared with 519,000 in February 1957. Belgian steel producers posted lower steel prices, amounting to as much as 12 pct for some grades. In **Japan**, the Ministry of Trade is considering restricting output of rolled products by some 30 pct, following recent cuts in ingot production by 20 pct. And because of large stocks of pig iron, the Ministry is expected to lift the export ban on pig iron.

L-D Converter Operates on Melted Scrap

The Gusstahlwerk Witten in Germany's Ruhr has no blast furnace, but nonetheless a 30-ton L-D oxygen converter was recently put into operation —the source of hot metal—scrap melted in a hot-blast cupola. The cupola is producing up to 20 tons per hr on a charge of some 75 pct scrap, and the balance open-hearth grade pig iron. Desulfurization of the hot metal is necessary. Hot-metal charge has a temperature of 2460°F, and ore is also used. The L-D converter is of an unsual design, with a hemispherically shaped bottom. Gusstahlwerk Witten produces varying types of alloy steels, but it is not a large-scale producer of carbon steels. The L-D converter is being used for the direct production of steel as well as for a duplexing operation with electric furnaces.

Open Hearth, ¾ Century Ago.



Painting of the operation of an early open hearth furnace about 1870. Original painting hangs in the museum at the Saugus Ironworks Restoration, Saugus, Mass.

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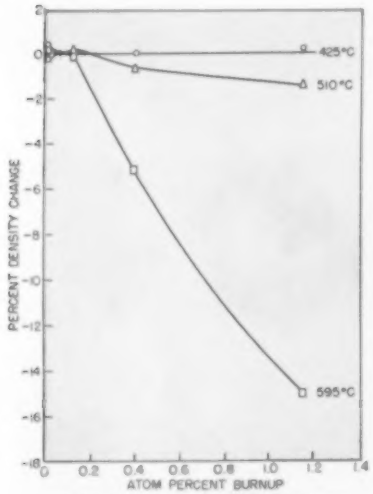
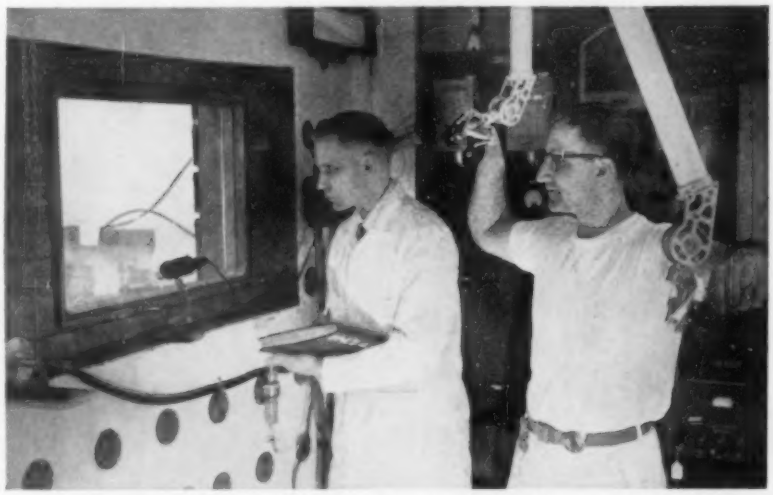
• • •

An example of the physical-metallurgical studies now under way in this area is the experimental work described below.



DENSITY CHANGES IN ZIRCALOY CLAD 8 w/o URANIUM-ZIRCONIUM ALLOYS ON POST-IRRADIATION ANNEALING



Dr. W. V. Johnston (left) recording data at post irradiation annealing cell.

POST-IRRADIATION ANNEALING OF URANIUM-ZIRCONIUM ALLOYS

To obtain information on the agglomeration mechanism and the extent of damage experienced, specimens of an 8 wt % enriched uranium-zirconium alloy which had been irradiated to a maximum of 42% of the U-235 atoms fissioned were annealed in vacuum furnaces at 425, 510 and 595°C. Percent density changes were determined as a function of temperature at an annealing time of 500 hrs. As can be seen in the graph, specimens of all burnups were stable at 425°C but volume increases of up to 15% were obtained at 595°C.

Additional information on the amount and rate of Kr and Xe diffusion and release from the fuel elements has been obtained by using β and γ counting techniques. The effects of irradiation and annealing on the temperature of phase transformations and on alloy structures are being studied by measurement of electrical resistivity, and use of advanced metallographic techniques.

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There are openings at the Laboratory for metallurgists and ceramists interested in development, application and fabrication of nuclear core materials. Degree is required; advanced degree and/or related experience preferred. (U.S. Citizenship) If you qualify, please send resume, including salary requirement, to: Mr. A. J. Scipione, Dept. 37-MP.

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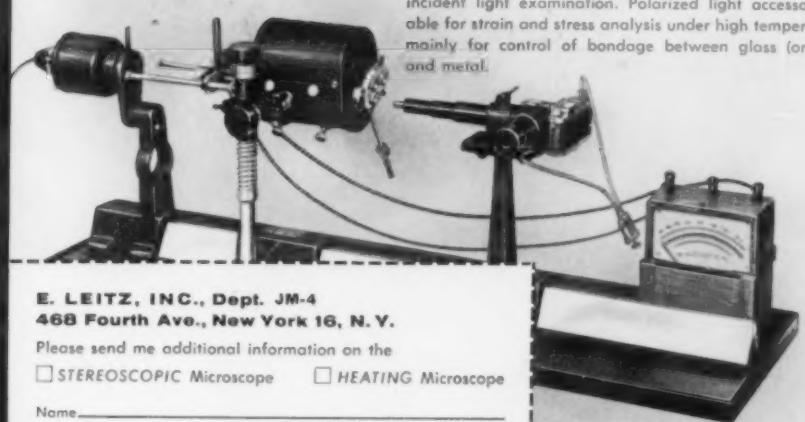

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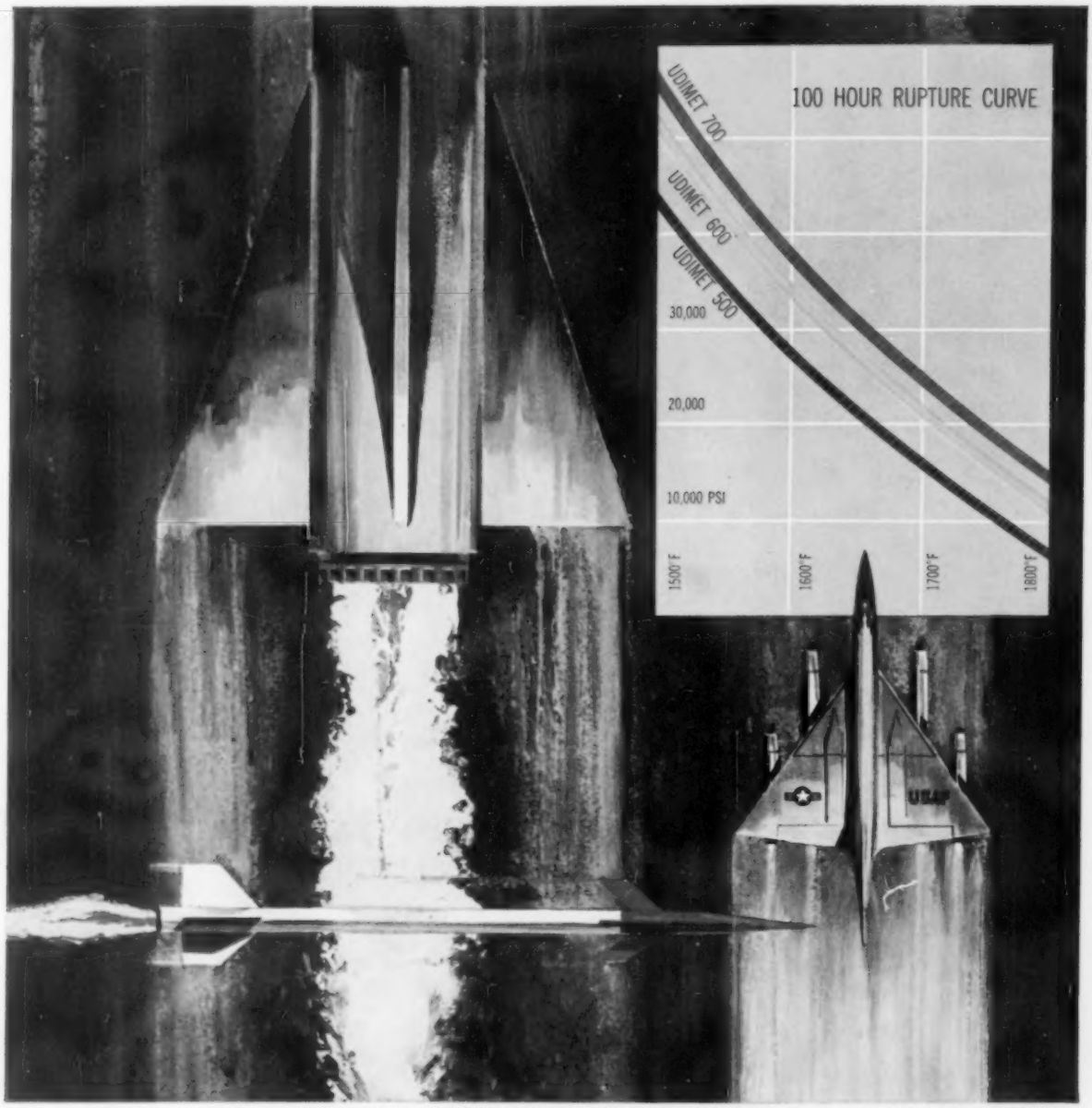

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PROGRAMS

Blast Furnace, Coke Oven, and Raw Materials Committee and National Open Hearth Steel Committee

The Statler Hotel, Cleveland, will be the scene of the 41st conference held April 14 through 16, 1958. Registration will be in the Mezzanine, Statler Hotel, 3 to 9 pm, Sunday, April 13; 8 am to 5 pm, Monday, April 14; 8 am to 5 pm, Tuesday, April 15; and 8 am to 4 pm, Wednesday, April 16. Special busses for the plant trip to Republic Steel Corp., on Wednesday, April 16, will leave the Statler Hotel, at 9:00 am.

National Open Hearth Steel Conference

Monday, April 14

9:30 to 10:30 am—Grand Ballroom

General Session

Welcoming Remarks: *M. F. Yarotsky*, Division Superintendent, Steel Production, South Works, United States Steel Corp., and General Chairman, National Open Hearth Steel Committee, AIME

Announcements and Reports

First Hundred Years of Basic Open Hearth Steelmaking: *L. F. Reinartz*, Consultant, Armco Steel Corp., Middletown, Ohio

McKune Award Paper

10:30 am to 12:15 pm—Grand Ballroom

Basic Operations Session on Charging of Cold Metallics

Chairmen: *L. T. Sanchez*, Open Hearth Superintendent, National Tube Div., United States Steel Corp., Lorain, Ohio, and *M. E. Nickel*, Assistant Open Hearth Superintendent, Wisconsin Steel Works, International Harvester Co., Chicago, Ill.

Use of Elevators: *MacBeth Sample*, General Foreman No. 2 Open Hearth Department, Armco Steel Corp., Middletown, Ohio

Use of Supercharger: *H. M. Parker*, Open Hearth Superintendent, Butler Works, Armco Steel Corp., Butler, Pa.

Control of Open Hearth Heat Weight: *E. J. Whittenberger*, Assistant Superintendent, No. 4 Open Hearth Department, Gary Works, United States Steel Corp., Gary, Ind.

Streamlining of Charging Cycles: *W. J. Flynn*, Assistant to Division Superintendent—Steel Production, Gary Works, United States Steel Corp., Gary, Ind.

10:30 am to 12:15 pm—Ohio Room

Acid Operations Session

Chairmen: *W. E. Holsinger*, General Superintendent, Foundry and Mill Machinery Div., Blaw-Knox Co., Coraopolis, Pa., and *Samuel Hough*, Open Hearth Superintendent, Mesta Machine Co., Homestead, Pa.

Hydrogen Analysis of Acid Open Hearth Steel: *J. G. Bassett*, Research Engineer, Acid Open Hearth Research Association, Pittsburgh, Pa.

Discussion: *J. H. Richards*, Chief, Process Metallurgy Div., United States Steel Corp., Pittsburgh, Pa., and *L. R. Cooper*, Chief Metallurgical Engineer, Heppenstall Co., Pittsburgh, Pa.

Solidification of Various Metals in Ingots and Sand Molds: *W. S. Pellini*, Superintendent, Metals Div., Naval Research Laboratory, Washington, D. C.

Discussion: *J. M. Dugan*, Works Manager and Chief Metallurgists, Ohio Steel Foundry Co., Lima, Ohio, and *F. H. Allison, Jr.*, Vice President, Blaw-Knox Co., Pittsburgh, Pa.

2:00 to 5:00 pm—Grand Ballroom

Operating Metallurgy Session

Chairmen: *Harold P. Gaw*, Works Metallurgist, Armco Steel Corp., Middletown, Ohio, and *William Rodgers*, Assistant Chief Metallurgist, Republic Steel Corp., Cleveland, Ohio

Description and Analysis of Various Steel Defects: *I. A. Sirel*, Steel Plant Metallurgist, Youngstown Sheet and Tube Co., East Chicago, Ind.

Results Using Exothermic Ferro Manganese—Panel Discussion:
R. L. Kimberly, Metallurgical Observer Foreman, Youngstown Sheet and Tube Co., East Chicago, Ind.
W. A. Olsen, Chief Process Metallurgist, South Works, United States Steel Corp., Chicago, Ill.
R. W. Farley, Director, Process Development, Republic Steel Corp., Chicago. Ill.
T. V. Wainwright, Practice Engineer Steelmaking, Bethlehem Steel Co., Bethlehem, Pa.

A Study of Wall Erosion in Wide Slab Molds, *R. W. Joseph*, Metallurgist, and *L. J. Trilli*, Supervising Metallurgist, Open Hearth and Blooming Mill Division, Metallurgical Dept., Inland Steel Co., East Chicago, Ind.

A Radioactive Tracer Study of Steel Surface Defects: *T. W. Crosta*, Process Control Metallurgist, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada

Yield Control by Means of Electronic Weighing: *Archie Black*, Manager of Electronic Laboratories, Republic Steel Corp.

2:00 to 5:00 pm—Ballroom, Manger Hotel

Refractories and Masonry Session (I)

Chairmen: *B. L. Dorsey*, Refractories Engineer, Jones & Laughlin Steel Corp., Pittsburgh, Pa., and *J. E. Harrod*, Assistant to Division Superintendent, Steel Production, South Works, United States Steel Corp., Chicago, Ill.

Basic Roofs in Great Britain: *J. Mackenzie*, Research and Development Department, The United Steel Companies, Ltd., Sheffield, England

Expansion Allowance on Basic Port Ends: *L. L. Wells, Jr.*, Superintendent, Masonry, and *T. P. Greaney*, Assistant to Superintendent, Masonry, South Works, United States Steel Corp., Chicago, Ill.

Progress With Basic Roofs:

1. Evaluation of Arched Versus Flat Basic Roofs: *A. H. Sommers*, Vice President, Operations, Keystone Steel and Wire Co., Peoria, Ill.
2. Progress Report on Basic Roofs: *C. W. Cravens*, Assistant District Manager, Republic Steel Corp., Cleveland, Ohio
3. Progress Report on Basic Roofs: *J. F. Pollack*, Superintendent, Open Hearths Department, Jones & Laughlin Steel Corp., Pittsburgh, Pa.
4. Progress Report on Basic Roofs: *L. D. Yager*, Open Hearth Superintendent, Laclede Steel Co., Alton, Ill.
5. Progress Report on Basic Roofs: *H. A. Muttach*, Works Manager, Hot Metal Div., Granite City Steel Co., Granite City, Ill.
6. Progress Report on Basic Roofs: *M. H. Stadler, Jr.*, Superintendent No. 2 Open Hearth, South Works, United States Steel Corp., Chicago, Ill.
7. Progress Report on Basic Roofs: *G. C. Lawton*, Superintendent No. 2 Open Hearth, Inland Steel Co., East Chicago, Ind.
8. Progress Report on Basic Roofs: *Hugh Barnes*, Consulting Engineer, Armco Steel Corp., Middletown, Ohio

Tuesday, April 15

9:30 am to 12:15 pm—Grand Ballroom

Refractories and Masonry (II)

Chairmen: *C. F. Henzelman*, Assistant Superintendent, Hot Metals Div., Granite City Steel Co., Granite City, Ill., and *J. A. Brooks*, General Foreman, Brick Department, Bethlehem Steel Co., Sparrows Point, Md.

Open Hearth Bottoms:

1. Carbon Sub-Hearth: *James Smith*, Open Hearth Superintendent, Republic Steel Corp., Warren, Ohio
2. Bottom Practice at No. 1 Open Hearth, Lackawanna Plant: *R. M. Jordan*, Assistant Division Superintendent, Open Hearths, Bethlehem Steel Co., Lackawanna, N. Y.
3. New Bottom Installations—Panel Discussion:
   M. H. Stadler, Jr., Superintendent No. 2 Open Hearth, South Works, United States Steel Corp., Chicago, Ill.
   T. D. Hess, Superintendent No. 1 Open Hearth, Indiana Harbor Works, Youngstown Sheet and Tube Co., East Chicago, Ind.
   G. A. Grosvenor, Superintendent Open Hearth, Colorado Fuel and Iron Corp., Pueblo, Colo.
   J. D. Sloane, Assistant General Foreman, Melting, Steel Co. of Canada, Ltd., Hamilton, Ont., Canada
   H. M. Kraner, Division Head, Ceramics, Bethlehem Steel Co., Bethlehem, Pa.

Pouring Aisle Refractories:

1. Effect of Nozzle Characteristics on Steel Pouring Streams: *R. E. Stoll*, General Supervisor, Research and Development, and *E. C. Rudolphy*, Chief Development Metallurgist, South Works, United States Steel Corp, Chicago, Ill.
2. Effect of Nozzle Size on Pouring Rates and Slab Surface of Rimming Steel: *A. T. Peters*, Metallurgist, Inland Steel Co., East Chicago, Ind.
3. Quality Control of Pouring Aisle Refractories: *C. L. Meloy*, Engineer, Ceramics, Bethlehem Steel Co., Bethlehem, Pa.

9:30 am to 12:15 pm—Ohio Room

Cold Metal and Basic Foundry Session

Chairmen: *J. A. Petroskas*, Chief Metallurgist, Phoenix Iron and Steel Co., Phoenixville, Pa., and *G. W. Teskey, Jr.*, Open Hearth Superintendent, Bethlehem Pacific Coast Steel Corp., San Francisco, Calif.

Carbon Black in Fuel Oil for Open Hearth Furnaces: *E. H. Swett*, Assistant to Open Hearth Superintendent, Bethlehem Pacific Coast Steel Corp., San Francisco, Calif.

Lukens Cement Hot Top Practice: *R. L. Bunting, Jr.*, Metallurgical Department, Lukens Steel Co., Coatesville, Pa.

Rapid Method of Bath Recarburization: *R. G. Waite*, Plant Metallurgist, and *Walter Mann*, Melter, General Steel Castings Co., Eddystone, Pa.

Continuous Waste Gas Analysis for Automatic Fuel Control in the Open Hearth Furnace: *C. J. McElhaney*, Open Hearth Superintendent, and *W. V. McNiece*, Open Hearth Fuel Engineer, Pittsburg Works, Columbia-Geneva Steel Div., United States Steel Corp., Pittsburg, Calif.

Sponge Iron as a Source of Metallics in the Steel Industry: *P. U. Gummeson*, Vice President and General Manager, Hoeganaes Sponge Iron Corp., Riverton, N. J.

2:00 to 5:00 pm—Ohio Room

Physical Chemistry of Steelmaking Session on Fundamental Aspects of Oxygen in Steelmaking

Chairmen: *C. W. Sherman*, Senior Research Associate, Jones & Laughlin Steel Corp., Pittsburgh, Pa., and *E. B. Hughes*, Metallurgical Engineer, Wheeling Steel Corp.

Engineering Thermochemistry of the Oxygen Steelmaking Process: *W. O. Philbrook*, Professor of Metallurgical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

Comparison of Dephosphorization and Desulphurization Between the Open Hearth Slag-Metal System and the Oxygen Process Slag-Metal System: *F. W. Luerssen*, Chief Research Engineer, Research and Development, Inland Steel Co., East Chicago, Ind.

Experimental Hot Metal Pre-Treating Tower: *J. M. Gaines*, Associate Technical Director, Linde Co., New York, N. Y., and *D. C. Hilty*, Manager, Information Research Group, Metal Research Laboratories, Electro Metallurgical Co., Niagara Falls, N. Y.

2:00 to 5:00 pm—Grand Ballroom

Operating and Combustion Session

Chairmen: *E. C. McDonald*, Chief Combustion Engineer, Republic Steel Corp., Cleveland, Ohio, and *M. E. Groat*, Open Hearth Superintendent, Great Lakes Steel Corp., Ecorse, Detroit, Mich.

Current Performance of Furnaces Producing in Excess of 20,000 Net Tons Per Month: Lead-off paper by *E. G. Kondas*, Assistant Superintendent Open Hearth, Republic Steel Corp., Cleveland, Ohio

Panel Discussion:

J. E. Hood, Assistant Open Hearth Superintendent, Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada

H. A. Parker, Open Hearth Superintendent, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

J. Anderton, Assistant General Superintendent Steel Production, The Broken Hill Proprietary Co., Ltd., Port Kembla, Australia

J. T. Clisham, Assistant Open Hearth Superintendent, Bethlehem Steel Co., Sparrows Point, Md.

Design, Maintenance, and Operation of Two-Pass Checkers: *J. Anderton*, Assistant General Superintendent Steel Production, The Broken Hill Proprietary Co., Ltd., Port Kembla, Australia

Gas Flow in an Open Hearth Model: *R. H. Jones*, Research Engineer, and *D. F. Brion*, Research Engineer, Bethlehem Steel Co., Bethlehem, Pa.

Continuous Oxygen Analysis for Combustion Control in the Open Hearth: *E. W. Hunziker*, Division Superintendent Open Hearth and Foundry, and *J. W. Bain*, Fuel Engineer, Open Hearth and Foundry, Columbia-Geneva Steel Div., United States Steel Corp., Geneva, Utah

Annual Fellowship Dinner

Tuesday, April 15

6:30 pm—Euclid Ballroom

Reception and Cocktail Party for dinner guests

7:00 pm—Grand Ballroom

Annual Fellowship Dinner

Toastmaster: *Van H. Leichliter*, President, American Steel and Wire Division, United States Steel Corporation.

Speaker: *Charles M. White*, Chairman of the Board of Directors, Republic Steel Corporation.

"The Great Delusions"

Blast Furnace, Coke Oven, and Raw Materials Conference

Monday, April 14

9:30 am to 12:15 pm—Euclid Ballroom

Blast Furnace Practice Session

Chairmen: *James Chisholm*, Superintendent of Central Furnaces and Docks, Cuyahoga Works, American Steel and Wire Div., United States Steel Corp., Cleveland, Ohio, and *R. J. Flanagan*, Superintendent, Blast Furnaces, Duquesne Works, United States Steel Corp., Duquesne, Pa.

Welcoming Remarks: *F. M. Hamilton*, Blast Furnace Department, Jones & Laughlin Steel Corp., Cleveland, Ohio, and General Chairman, Blast Furnace, Coke Oven, and Raw Materials Committee, AIME

Blast Furnace Operation With Humidified Blast: Preprinted by *Richard Wilson*, Assistant Superintendent Plant No. 2 Blast Furnaces, Inland Steel Co., East Chicago, Ind.

Process Analysis of Operation With Steam and Oxygen in the Blast Furnace: *T. E. Dancy*, Research Supervisor, Jones & Laughlin Steel Corp., Pittsburgh, Pa., *A. T. Sadler*, Blast Furnace Superintendent, Jones & Laughlin Steel Corp., Aliquippa, Pa., and *H. N. Lander*, Research Supervisor, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

Sinter Cooling—an Important Part of the Sinter Plant: *H. Wendeborn*, Director, Lurgi Co., Frankfort-am-Main, Germany, *F. M. Hamilton*, Blast Furnace Department, Jones & Laughlin Steel Corp., Cleveland, Ohio, and *G. Brandes*, Lurgi Co., Frankfort-am-Main, Germany

Smelting of Titaniferous Ores: Preprinted paper by *H. U. Ross*, Professor of Metallurgical Engineering, University of Toronto, Toronto, Ontario, Canada

Annual Luncheon and Business Meeting, Blast Furnace, Coke Oven, and Raw Materials Committee

Tuesday, April 15

12:30 pm—Pine Room

F. M. Hamilton, Chairman

Everyone attending the Blast Furnace, Coke Oven, and Raw Materials Conference is invited to attend this luncheon and annual business meeting.

(Tickets $3.50, tips and tax included; see page 4)

9:30 am to 12:15 pm—Pine Room

Coal Preparation Session

Chairmen: *M. O. Holowaty*, Research Engineer, Inland Steel Co., East Chicago, Ind., and *J. A. Hall*, Supervisor, Quality Control, Blast Furnace and Coke Oven Div., Ford Motor Co., Dearborn, Mich.

Recently Developed Burstlein/Longwy Process for Coke Production From Bituminous and Non-Bituminous Coals: *E. M. Burstlein*, President, Sovaco, Paris, France

Some Practical Aspects of the Degradation of Blast Furnace Coke During Handling: *J. G. Price*, Junior Technologist, and *J. D. Clendening*, Supervising Technologist, Applied Research Laboratory, United States Steel Corp., Monroeville, Pa.

Use of Statistics in Coal Processing: *W. M. Bertholf*, Preparation Engineer, Colorado Fuel and Iron Corp., Pueblo, Colo.

2:00 to 5:00 pm—Euclid Ballroom

Recent Blast Furnace Developments Session

Chairmen: *N. W. Lindbloom*, Superintendent of Blast Furnaces, Edgar Thompson Works, United States Steel Corp., Pittsburgh, Pa., and *J. R. Lowe*, Superintendent, Blast Furnaces, Pittsburgh Works, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

Temperature Distribution in the Blast Furnace Stove: Preprinted paper by *W. A. Knepper*, Assistant Division Chief, Raw Materials Engineering Div., and *W. W. Campbell*, Technologist, Applied Research Laboratory, United States Steel Corp., Monroeville, Pa.

Automatic Stove Changing: *A. J. Karsten*, Specialty Section Manager, Freyn Department, Koppers Co., Inc., Pittsburgh, Pa., and *R. T. Hanna*, Assistant Blast Furnace Superintendent, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

An Investigation of Gas Flow in a Small Blast Furnace Using a Mercury Tracer Method: *H. W. Hosking*, Senior Research Officer, The Broken Hill Proprietary Co., Ltd., Shortland, New South Wales, Australia: *W. O. Philbrook*, Professor of Metallurgical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa., and *N. B. Melcher*, Chief, Pyrometallurgical Laboratory, U. S. Bureau of Mines, Region V, Pittsburgh, Pa.

Desulphurization of Hot Metal—A Production Evaluation: Preprinted paper by *A. J. Deacon*, Physical Chemist, *D. B. Powell*, Metallurgist, and *E. C. Rudolphy*, Chief Development Metallurgist, South Works, United States Steel Corp., Chicago. Ill.

2:00 to 5:00 pm—Pine Room

Coke Session

Chairmen: *J. D. Price*, Superintendent, By-Product Coke Plant, Colorado Fuel and Iron Corp., Pueblo, Colo., and *C. W. Drake*, Divisional Superintendent of Coke Ovens and Docks, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada

Choice of Constituents of a Coke Blend: *R. Loison*, Director of Research, Centre d'Etudes et de Recherches des Charbonnages de France, Paris, France, and *P. Foch*, Director, Station Experimentale de Marienau, Forbach, France

Carbonizing Tests With Tuscaloosa Oven: Studies of Oven Width, Flue Temperature, and Coking Rate: Preprinted paper by *J. B. Gayle*, Chief, Coal Laboratory, and *W. H. Eddy*, Fuels Technologist, United States Bureau of Mines, University, Ala.

Use of a Thirty Pound Test Oven for the Rapid Assaying of the Coking Strength of Coals: *J. G. Price*, Junior Technologist, *R. W. Shoenberger*, Assistant Technologist, and *B. Perlic*, Assistant Technician, Applied Research Laboratory, United States Steel Corp., Monroeville, Pa.

Tuesday, April 15

9:30 am to 12:15 pm—Parlors 1, 2, 3

By-Product Session

Chairmen: *A. D. Shattuck*, Superintendent Coke Plants, Blast Furnace Division, Great Lakes Steel Corp., Ecorse, Detroit, Mich., and *W. H. Matthews*, Superintendent, No. 2 Coke Plant, Inland Steel Co., East Chicago, Ind.

Wilputte Centrifugal Extractor Phenol Plant: Preprinted paper by *R. O. Bowman*, Superintendent, Coke Plant, Weirton Steel Co., Weirton, West Va.

Phenol Extraction: *A. H. Arbogast*, Engineer of Combustion, Fuel Div., Bethlehem Steel Co., Bethlehem, Pa.

Continuous Chemical Purification Including Removal of Thiophene From Coke Oven Light Oil: *L. T. Hartmann*, Wilputte Coke Oven Div., *J. J. Lawton*, Semet-Solvay Div., and *W. E. Carbone*, Project Manager, Wilputte Coke Oven Div., Allied Chemical and Dye Corp., New York, N. Y.

Forecast of Market Conditions: *T. J. Kinsella*, President, Barrett Div., Allied Chemical and Dye Corp., New York, N. Y.

9:30 am to 12:15 pm—Euclid Ballroom

Raw Materials and Burden Session

Chairmen: *F. G. Anderko*, Assistant Superintendent Blast Furnace Division, Bethlehem Works, Bethlehem Steel Co., Bethlehem, Pa., and *J. S. McMahan*, Superintendent Blast Furnaces, Steel Co. of Canada, Hamilton, Ontario, Canada

Results of Operation With an Experimental Blast Furnace: *J. J. Bosley*, Supervising Technologist, Raw Materials Engineering Division, Applied Research Laboratory, United States Steel Corp., Monroeville, Pa., and *M. B. Royer*, Supervising Extractive Metallurgist, U. S. Bureau of Mines, Region V, Bruceton, Pa.

Sintering of High-Grade Hematite Ore With Special Reference to Lime Additions and Reducibility: Preprinted paper by *E. Klein*, Development Manager, South African Iron and Steel Industrial Corp., Ltd., Iscor Headquarters, Pretoria, Transvaal, South Africa

Canadian Iron Ore: Preprinted paper by *P. E. Cavanagh*, Director of Engineering and Metallurgy, Ontario Research Foundation, Toronto, Ontario, Canada

Fuels for Sintering: *T. L. Myron*, Supervising Technologist, Applied Research Laboratory, United States Steel Corp., Monroeville, Pa.

2:00 to 5:00 pm—Euclid Ballroom

Joint Blast Furnace and Coke Oven Session

Chairmen: *H. A. Strain*, Consultant, Pittsburgh, Pa., and *J. S. McMahan*, Superintendent Blast Furnaces, Steel Co. of Canada, Hamilton, Ontario, Canada

Iron-Coke Process: Preprinted paper by *H. Barking*, General Manager, and *C. Eymann*, Chief Chemist, Bergwerkgesellschaft Walsum, Walsum, Niederrhein, Germany.

Iron Making—Past Achievements, Present Limitations, Future Prospects: *J. M. Stapleton*, Assistant to Vice President, United States Steel Corp., Pittsburgh, Pa.

Effect of Coke Size on Blast Furnace Performance—Panel Discussion:
R. P. Liggett, Chairman, Blast Furnace Committee, Republic Steel Corp., Cleveland, Ohio

D. C. Coleman, Director, Operations and Development, Wilputte Coke Oven Div., Allied Chemical and Dye Corp., New York, N. Y.
W. D. Millar, Division Superintendent, Furnaces and Coke Works, United States Steel Corp., Fairless Hills, Pa.
Kurt Neustaetter, Superintendent, Plant No. 3, Blast Furnaces, Inland Steel Co., East Chicago, Ind.

Annual Fellowship Dinner

Tuesday, April 15

6:30 pm—Euclid Ballroom

Reception and Cocktail Party for dinner guests

7:00 pm—Grand Ballroom

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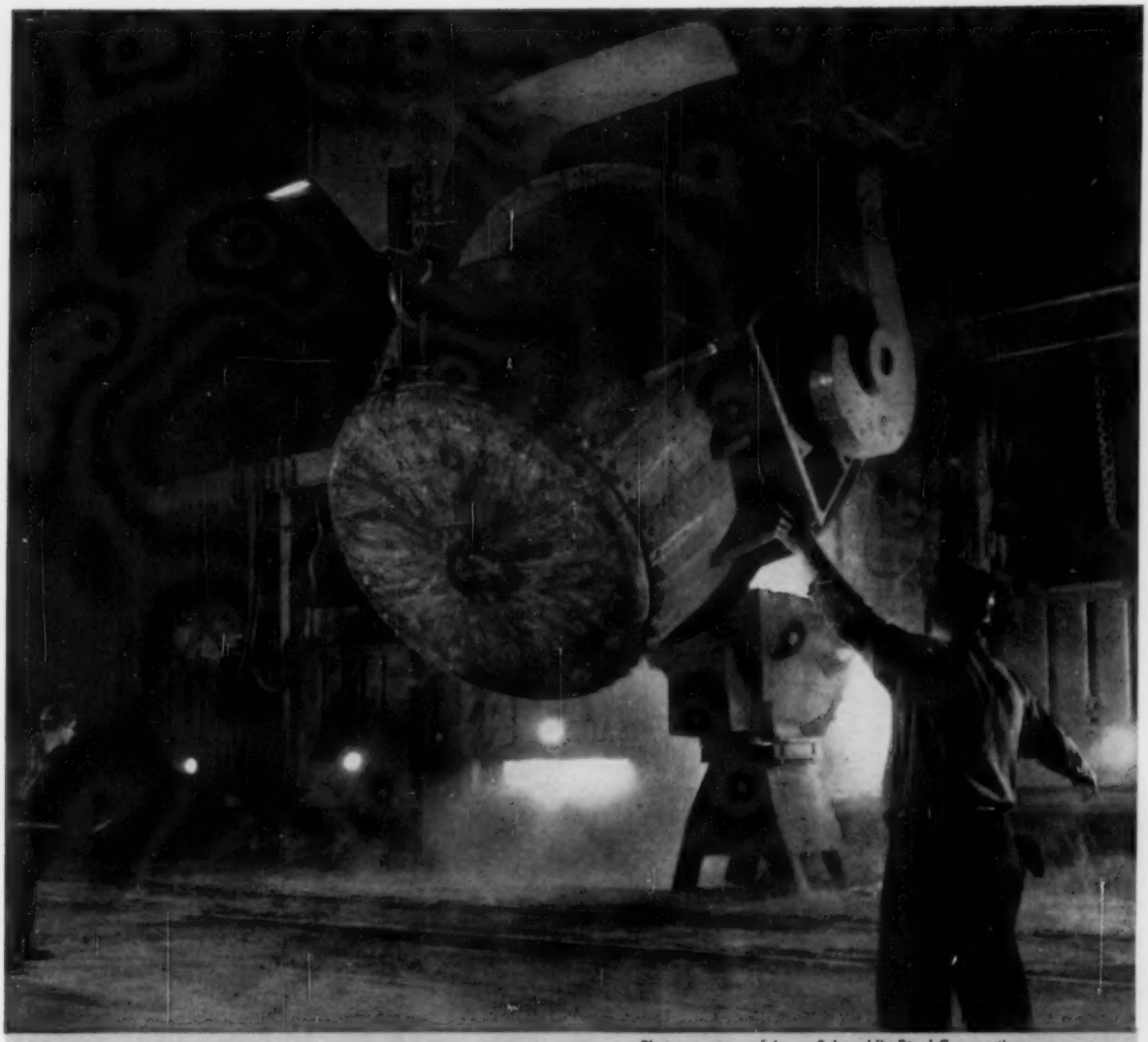
Toastmaster: *Van H. Leichliter*, President, American Steel and Wire Division, United States Steel Corporation.

Speaker: *Charles M. White*, Chairman of the Board of Directors, Republic Steel Corporation. "The Great Delusions"



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Blast Furnace and Open Hearth Committee Reports

The Blast Furnace Coke Oven and Raw Materials Committee Iron and Steel Division has prepared a most outstanding and informative program for the 1958 April Conference.

Scheduled, are seven sessions to cover the field of their activities. Three of these sessions will deal with coal, coke, and their by-products. Two sessions will be devoted to blast furnace operation, while another meeting will present discussions of blast furnace burdens and sintering. A final session will be a joint meeting of coke plant and blast furnace personnel.

Authors of the technical papers represent major companies in the United States, Canada, and South Africa, and it is fortunate to have their experiences available.

The committee has given serious thought during the year to the possibility of having a book prepared on Blast Furnace practice. A concrete recommendation is now available, and will be presented at the April Conference.

The feasibility of establishing local chapters of the committee has been studied, and necessary arrangements are being made with the parent organization so that this can be accomplished in towns or areas as desired by interested groups.

Local Section Activities

Pittsburgh Section

During the past year the **Pittsburgh Section** held an Iron and Steel Division dinner-meeting jointly with the AIME Pittsburgh Section on March 28, at the Gateway Plaza. Featured speaker for the occasion was Dr. Bruce Old, from the Arthur D. Little Co., who discussed *Direct Reduction Processes.*

The annual spring golf party held at the South Hills Country Club, saw a turnout of 224 members and guests playing golf and an attendance of 460 at the evening dinner. J. T. Meell served as chairman of the arrangements committee and D. H. McBride, chairman of the Pittsburgh Section, NOHC, presided as Toastmaster.

R. M. BARNHART

Alco Products Inc.
Latrobe, Pa.
Chairman
Pittsburgh Section

The 12th annual off-the-record meeting took place on Nov. 1, 1957 at the Penn-Sheraton Hotel, with a total registration of 828 including 47 Indian students as guests. The meeting embraced the joint effort of all local divisions of AIME, including the Coal Div., IMD, Petroleum Div., and the Minerals and Metals Economic Committee, in addition to the NOHC. Mr. D. H. Davis and C. L. Owens served as general program chairmen, assisted by the various division chairmen and their committees.

Through the courtesy of the suppliers, a cocktail party was held prior to the Fellowship Dinner, the latter being attended by 424 members and guests. A total of 145 engineering students attended and participated in the technical sessions.

Toastmaster for the event was D. L. McBride. Also attending the dinner were Grover J. Holt, AIME president, Walter A. Dean, AIME Vice President, and M. F. Yarotsky, Chairman, NOHC. Special tribute was paid to Jay H. Richards, F. L. Toy Award Winner; J. T. Brown, Legion of Honor Award Winner; and J. H. Henderson, Student Award Winner. Guest speaker at the dinner was Prof. M. S. Sandaram, Economic and Cultural Advisor to the Indian Embassy.

The current officers for the Pittsburgh Section—NOHC are: R. M. Barnhart, Chairman, Alco Products Inc.; E. E. McGinley, Vice Chairman, United States Steel Corp.; E. B. Snyder, Secretary, Wheeling Steel Corp.; and J. H. Smith, Treasurer, Blast Furnace and Steel Plant.

The Board of Directors are: J. L. Peterson-1958, Electro Metallurgical Corp.; K. C. Shearer—1958, United States Steel Corp.; G. P. Whitaker—1958, Wheeling Steel Corp.; J. N. Albaugh—1959, Jones and Laughlin Steel Corp.; J. G. Bassett—1959, Acid Open Hearth Research Assn.; R. S. Crowell—1959, United States Steel Corp.; R. G. Dean—1960, Crucible Steel Co.; H. R. Loxterman—1960, Blaw-Knox Co.; and F. R. Pullen—1960, Bethlehem Steel Co.

The Section's plans for the future include the spring golfing outing at the Edgewood Country Club on Monday, June 16, 1958, and the Thirteenth Annual-off-the-record meeting, Friday, Nov. 7, 1958, at the Penn-Sheraton Hotel.

Chicago Section

The Chicago Section had an eventful year. The spring dinner meeting was held at Phil Smidt's Restaurant on May 6, 1958, with the entire event being devoted to open-hearth bath temperature control. W. J. Flynn, U. S. Steel Corp., Gary Steel Works, highlighted this meeting with the presentation of his paper, *Contribution of Bath Temperature Control to Improved Open Hearth Production Rates.* R. W. Phelps, of Inland Steel Co., served as Technical Chairman for the occasion.

The tenth annual golf party held at the Midlothian Country Club on Sept. 10, 1957, was enjoyed by an attendance of 478, with 221 participants in the golf tournament.

On Oct. 7, 1957, a fall dinner meeting was held at Phil Smidt's, presided over by Technical Chairman, F. R. Smith, Jr., of Gary Steel works, U. S. Steel. The

leadoff paper at the meet, which featured discussions of furnace charging practice, was presented by S. Penny, Gary Steel works, U. S. Steel.

The scene of the all-day off-the-record meeting was at the Del Prado Hotel on March 12, 1958. Subjects discussed included charging of cold metallics, evaluation of double vs. single pass checkers, basic port ends, open hearth safety, optimum scheduling for obtaining quality and maximum production, pouring practice, steel defects, and modern methods for chemical analysis.

Section officers for the coming year are: Chairman, H. W. Erler, Gary Steel works, U. S. Steel; Vice Chairman, M. E. Nickel, Wisconsin Steel works, International Harvester; and Secretary-Treasurer, A. M. Kroner, Inland Steel.

H. W. ERLER

U. S. Steel Corp.,
Gary, Ind.
Chairman
Chicago Section

Southwestern Section

Two important events culminated the 1957 activities of the **Southwestern Section.** The Hotel Lennox, St. Louis, Mo. marked the site of the spring meeting held on Feb. 8, 1957. Approximately 130 persons registered, 95 of whom attended the all-day technical session. All those who registered attended the Fellowship dinner which followed.

Hosts for the annual Globe Trotters' meeting held in Houston, Texas, on Oct. 3 and 4, 1957, were the Sheffield Div. of the Armco Steel Corp. Members and guests of AIME visited the plant of the Sheffield Div. of Armco Steel Corp. on the Houston Ship Channel, Thursday, October 3. An excellent luncheon was served at the Sheffield Gun Club, and members and guests were later transported by bus and limousine to the Shamrock-Hilton Hotel.

On October 4, the technical session held at the Shamrock-Hilton Hotel was attended by 225, believed to be the largest ever to attend a Southwestern Section meeting. Guests included 17 representatives from steel plants in Mexico. While the technical session was in progress, the wives of members and guests were conducted on a citywide tour of Houston, after a luncheon at the Junior League Club, as guests of Sheffield.

After Friday's technical session, members and guests enjoyed a boat trip down the Houston Ship Channel to the San Jacinto Inn, where the Suppliers' Cocktail Party was held, a highlight of the day's activities. The Fellowship dinner at the Inn followed, and was attended by 200 members and guests.

The future, 1958 Globe Trotters' meeting is planned for October, in Birmingham, Ala., with TC&I as the host.

The new Chairman of the Southwestern Section is George Grosvenor, Open Hearth supt., Colorado Fuel & Iron Corp., Pueblo, Colo.

Detroit Section

The **Detroit Section** lead off last year with a two day regional meeting, March 18 to 19, 1957, jointly sponsored with the Detroit Chapter of AIME. Probably the first meeting of this kind devoted entirely to one subject; the topic was *Deep Drawing Steels*, with the program covering process metallurgy and physical metallurgy of deep drawing steels from raw materials to fabrication. A cocktail party and banquet followed the meeting, which was attended by over 400 for the two days. Bound copies of the proceedings were mailed to all registrants.

The first meeting of 1958 was launched in the Horace Rackham Building. One hundred and ten persons attended this off-the-record type dinner meeting, whose topic was *Spraying Applications, Practices and Techniques.* Discussions covered various types of batch feeders and guns, along with material usage and application, with W. J. Scharfenaker, Great Lakes Steel Corp., serving as Moderator. On the panel were Paul Lindberg, McLouth Steel; Roland Kenny, Ford Motor Co.; and Anthony Niemeth of J. & L., Stainless Div.

Coming plans of the Section include an all day session in Detroit, May 21, 1958. One half of the day will be devoted to technical sessions and the remainder half day will be occupied with a local plant visit, to be followed by a banquet. Headquarters for this meet will be the Hotel Fort Shelby.

The Dearborn Country Club will mark the annual golf party on Sept. 16, 1958. One additional meeting will be held at the Rackham Building in late October, the date to be announced later in the year.

M. E. GROAT

Great Lakes Steel Co.,
Ecorse, Detroit, Mich.
Chairman
Detroit Section

Southern Ohio Section

The annual golf outing, June 7, 1957, held at Elk's Country Club, Middletown, Ohio, opened the bill for the **Southern Ohio Section,** with 95 members attending.

Columbus, Ohio, was the scene of the twenty-first annual technical conference held at the Deshler-Hilton Hotel, Oct. 18 and 19, 1957. Co-Chairmen for the morning operating session were O. V. Ireland, supervising metallurgist, Armco Steel Corp., Middletown, Ohio; and A. W. Meihack, supt., Steel div., Empire Steel Corp., Mansfield, Ohio. Papers were presented by L. F. Reinartz, Armco Steel Corp.; R. K. Thornberry, Acme Newport Steel Co.; T. J. Murray, Armco Steel Corp., Ashland, Ky.; Tom Burney, Armco Steel

Corp.; Mac Sample, Armco Steel Corp.; and William C. Jack, Armco Steel Corp.

The afternoon session on furnace practice was presided over by Co-Chairmen R. K. Thornberry, supt., steel melting, Acme Newport Steel Co., Newport, Ky.; and T. J. Murray, asst. to the O. H. supt., Armco Steel Corp., Ashland, Ky. Papers were presented by C. W. Cravens, Republic Steel Corp.; Tom Moore, Armco Steel Corp.; J. W. Flowers, Armco Steel Corp.; Charles Hesselman, Acme Newport Steel Co.; and F. E. Williams, Armco Steel Corp. Total registration for the sessions was 190.

The Hall of Mirrors at the Deshler-Hilton Hotel, set the stage for the Fellowship dinner. Toastmaster was M. F. Yarotsky, National Chairman, NOHC, and the featured speaker was Dr. David Guy Powers, Queens College, New York, N. Y.

Coming events for the new year include the annual golf outing to be held June 6, 1958 at the Summit Hills Country Club, Ft. Mitchell, Kenton County, Ky.; and the twenty-second conference to be held Oct. 3 and 4, 1958 at the Deshler-Hilton Hotel in Columbus, Ohio.

Officers for the Section are: Chairman, P. G. Sammet, supt., O. H., Armco Steel Corp., Ashland, Ky.; Vice Chairman, R. K. Thornberry, supt., steel melting, Acme Newport Steel Co., Newport, Ky.; and Secretary-Treasurer, O. W. Morris, combustion engineer, Armco Steel Corp., Ashland, Ky.

P. G. SAMMET

Armco Steel Corp.,
Ashland, Ky.
Chairman
Southern Ohio Section

Buffalo Section

The fourth annual golf party of the **Buffalo Section** was featured at Wanakah Country Club on May 23, 1957 with 139 registrants. A dinner highlighted the evening, at which time prizes were distributed through the courtesy of the Open Hearth Suppliers' Committee.

The Royal Connaught Hotel, Hamilton, Ont., Canada, keynoted the eighth annual Fall meeting, held on Nov. 12, 1957 with 235 registrants. A large percentage of the registrants were conducted on a tour through No. 2 Open Hearth plant of Steel Co. of Canada.

The afternoon technical session was conducted by C. E. Moyer, O. H. supt., Republic Steel Corp., and J. E. Hood, asst. O. H. supt., Steel Co. of Canada, who presided as technical session Chairman and Co-Chairman. Principal speakers were R. M. Jordan, asst. supt. of Open Hearths, Bethlehem Steel Corp., the Discussion Leader. The panelists were comprised of A. I. Gorman, Steel Co. of Canada, F. J. Todd, Republic Steel Corp., and J. Bingleman, Dominion Foundaries and Steel.

J. R. ATKINSON

Dominion Foundries &
Steel Ltd.,
Hamilton, Ont., Canada
Chairman
Buffalo Section

A film presentation, *The Germ*, was shown, through the courtesy of U. S. Steel Corp. followed by a general discussion from the floor. The windup of events was the Annual Banquet, held in the evening.

Future events scheduled for this year by the Section include the 1958 golf party to be held May 22, 1958 at the Wanakah Country Club, and the 1958 Annual Fall Meeting scheduled for November 11th at the Hotel Statler, Buffalo.

Officers of the Buffalo Section are: Chairman, John R. Atkinson, supt. of melting, Dominion Foundries & Steel Ltd., Hamilton, Ont., Canada; Vice Chairman, C. E. Moyer, O. H. supt., Republic Steel Corp., Buffalo, New York; and Secretary, Harry A. Morlock, General Refractories Co., Buffalo, New York.

Northern Ohio Section

Officers for the coming year of the **Northern Ohio Section** are: Chairman, E. J. Brandon, asst. div. supt., Steel Production div., Ohio works, U. S. Steel Corp.; and Secretary-Treasurer, F. J. Herman, supt., Bessemer dept., Ohio works, U. S. Steel Corp.

The Section is currently making preparations for its Annual Golf Party, now that their off-the-record meeting has been staged.

E. J. BRANDON

U. S. Steel Corp.
Youngstown, Ohio
Chairman
Northern Ohio Section

(Continued on page 256)

OPEN HEARTH

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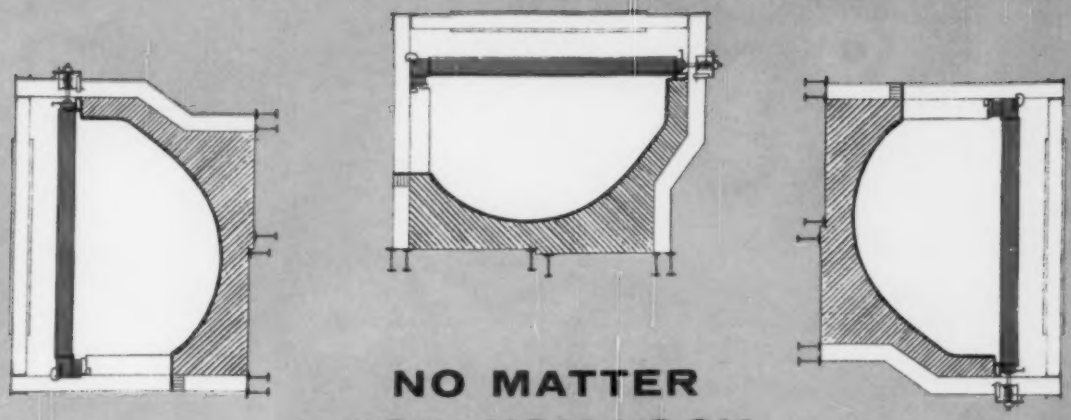
BY DETRICK



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NOHC Local Section Reports

(*Continued from page 254*)

Western Section

Four eventful meetings were launched by the **Western Section** during last year. On Sept. 17, 1957, 55 members gathered at the Roger Young Auditorium in Los Angeles for a meeting presented by the Electric Furnace dept. of Bethlehem Pacific Coast Steel Corp.'s Los Angeles plant. Guest speaker was G. M. Prioli, who discussed the effect of tap voltages on electric furnace operation.

On November 26, 1957, a joint meeting was held with the **Southern California Section** of AIME, with guest speakers Dr. N. P. Allen, National Physical Laboratory, Teddington, England, and Dr. C. Crussard of the French Iron and Steel Inst. They spoke jointly on the metallurgical research development in their respective countries. Thirty-one attended from the local section of the National Open Hearth Steel Committee and 45 from the Southern California Section.

Scheduled for the middle or latter part of May, (to be announced), will be a field trip through Kaiser Steel Corp.'s new expanded facilities.

Officers for the 1957-58 season are: Chairman, W. F. Bowers, Kaiser Steel Corp., Fontana, Calif.; Vice Chairman, Julio Venturini, Bethlehem Pacific Coast Steel Corp., Los Angeles, Calif.; and Secretary-Treasurer, Bruce J. Paulsen, Missouri Refractories Co., Los Angeles, Calif.

W. F. BOWERS, JR.

Kaiser Steel Corp.
Fontana, Calif.
Chairman
Western Section

Cleveland Section

The **Cleveland Section** wound up its active 1956 and 1957 season on June 20, 1957 with a dinner-dance at the Lake Shore Hotel attended by 63 couples.

Well attended past technical meetings manifested great interest and considerable discussion was participated in by a large percentage attending. During the year, five executive committee meetings were held: May 5, 1957, July 30, 1957, Sept. 27, 1957, and Feb. 27, 1958. In the May 15, 1958 session, new officers will be elected for the next two years.

Interest in the local section as well as in the national chapter is continually growing, and considerable benefits have been recognized both by the participating people and those companies who have active members. In 1957 the active membership rose to 112, as compared to 82 the previous year.

C. W. CRAVENS

Republic Steel Corp.,
Cleveland, Ohio
Chairman
Cleveland Section

Eastern Section

On Friday, May 10, 1957, 296 members of the **Eastern Section** participated in a well planned and well conducted tour through the plant of Wickwire Spencer Steel Div. of the Colorado Fuel and Iron Corp. at Clayton, Del. Many suppliers and steel producers were represented in the group. The tour included the Open Hearth, Plate Mill, Fabrication, and Flange depts. Following the plant visitation, the group was taken by bus to Club 31, Chester, Pa., for lunch, where they were guests of the host company.

The Sections first golf party was staged on June 28, 1957, at the Coatesville Country Club, Coatesville, Pa. One hundred and nine members and suppliers attended the party, at which all grades of golf were played. Prizes, donated by the Suppliers Committee, were awarded to the participants. A buffet lunch was served, and an excellent steak dinner was followed by entertainment. It is the hope of the Section that the golf party will be made an annual affair.

The Sheraton Hotel in Philadelphia opened its doors to the Section on Friday, Oct. 11, 1957, for the eleventh annual technical conference, with an attendance by 229 guests. The reading of the award winning paper, *Hot Top Material—a Study in Material Handling*, by Wallace F. Low, of the John A. Roebling's Sons plant of the Colorado Fuel and Iron Co. was first on the program. The remainder of the morning was devoted to a panel discussion, having as its theme, ways of reducing open hearth costs. Harry Davis, Supt. of No. 3 O. H. Plant, Lehigh Div., Bethlehem Steel Co., Bethlehem, Pa. was the Moderator of the discussions which continued until adjournment for lunch.

The afternoon session was under the chairmenship of George S. Baldwin, Standard Steel Works; and J. Gardner Blythe of the Roebling Plant of Colorado Fuel and Iron Co. An interesting talk on *Steel Plants in Europe* by R. Russell Fayles, Lukens Steel Co., started the session. The balance of the session consisted of the following papers: *Contributions of Bath*

(*Continued on page 258*)

WALSH'S ANSWER TO THE PROBLEM OF JOINT EROSION IN LADLE AND FIREBRICK FURNACE LININGS

AT GRANITE CITY STEEL COMPANY—Mid-America's dependable source of flat, rolled steel, a protective coating of Walsh METALOK is being applied to Walsh Ladle Brick in lining of 300 ton ladle.

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SPECIALISTS IN REFRACTORIES OF HIGH BULK DENSITY AND LOW POROSITY

NOHC Local Section Reports

(*Continued from page 256*)

Temperature Control to Improve Open Hearth Production Rates, by W. J. Flynn, U. S. Steel Corp., Gary, Ind.; *The Use of a Super-Charger*, by H. M. Parker, Armco Steel Corp., Butler, Pa.; *The Use of a Continuous Oxygen Analyzer*, by R. Sundstrom, U. S. Steel Corp., Fairless works; and *Rapid Furnace Rebuild*, by A. V. Leon, Bethlehem Steel Co., Bethlehem, Pa.

The Eastern Suppliers Assn. were hosts to the group at a reception prior to dinner at 6:30 p.m., in the ballroom. The dinner-meeting was attended by members of the Executive Board: D. R. Mathews, R. R. Fayles, and National Chairman, M. E. Yarotsky, who addressed the group after dinner. A talk on a half century in steel was also given by Harry Davis of Bethlehem Steel Co. Following the talks, the Suppliers Assn. furnished music and entertainment.

The Section's plans for the coming year include a golf party to be held in June at the Coatesville Country Club, Coatesville, Pa.; and the annual technical conference scheduled for Oct. 10, 1958, at the Warwick Hotel, Philadelphia, Pa.

TRANSACTIONS

OF THE METALLURGICAL SOCIETY OF AIME

Articles included in the April issue:

- Sinter Roasting of Galena Concentrates at the Rönnskär Works, Sweden
  by Wallden, Lindvall, and Gorling
- Equilibria of Molten Iron and Liquid Slags of the System CaO-SiO_2-(FeO).
  by Bishop, Grant, and Chipman
- Nucleation of Solid State Transformations
  by Morris Cohen
- Theory of Brittle Fracture in Steel and Similar Metals
  by A. H. Cottrell

. . . and many, many, more

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EDITORIAL

ANNUAL REPORT

Historically, 1957 will be remembered as the year that The Metallurgical Society of AIME was established. Problems requiring virtually immediate solution were recognized and tackled by the new Board of Directors of the Society and by the Executive Committees of the three constituent divisions. Of major importance was the problem of the Society publications—how to provide, within stringent financial limitations, a journal of interest to the general membership, and publish transactions of interest to a more limited segment of the membership.

Staff realignment was required to provide for resulting publication changes, and for increased services from the Secretary's office. Administrative Rules to accompany the approved Society Bylaws were written and approved. Division Bylaws were reviewed in order that they conform with changes in the Society structure. Society Bylaws were amended as dictated by experience in the first year of operation.

A Society Projects Fund was established to provide revenue for the Society to embark on special projects of service to the members, and of an income-earning nature that might be impossible to accomplish if the Society were limited only to its operating budget.

Attention was given to the major problem of increasing membership of The Metallurgical Society of AIME. Publications and technical programs were recognized as important factors in increasing the membership rosters. Programming is being carried out on a long-range basis in order to meet adequately the future needs of the Society.

Operationally, 1957 was marked by an increased number of *Regional Conferences*, and increased attendance at established conferences. Greater service was rendered to members through an increased number of special publications on metallurgical subjects. Membership experienced moderate growth.

Reorganization of Publications

The Board of Directors of The Metallurgical Society of AIME approved on November 6, 1957, a new publication program that had been under study for over a year. Briefly the plan provides for separating the TRANSACTIONS from the JOURNAL OF METALS and issuing them bimonthly as a separate publication to be known as the TRANSACTIONS OF THE METALLURGICAL SOCIETY OF AIME. The JOURNAL OF METALS thus provides more space for professional articles and technical papers of a descriptive or timely nature.

The JOURNAL OF METALS will continue to be sent to the entire membership of The Metallurgical Society of AIME as part of their dues. As before, it will be available to members of other AIME Societies for $4.00 per year, and to the public for $8.00 per year.

A revolutionary change has been effected in that a charge, distinct from dues, is being made of both members and non-members to receive TRANSACTIONS. The bi-monthly issues of the TRANSACTIONS OF THE METALLURGICAL SOCIETY OF AIME will be available to AIME members for $5.00 per year, and to the public for $20.00 per year. The first issue appeared in February, 1958.

It should be noted that the extensive Transactions publications program of The Metallurgical Society of AIME has been possible in recent years only due to considerable financial support from industry and prior to that from other groups in the Institute. Hence, it was felt that a more realistic program should be developed that would eventually end the expediency of soliciting industrial support. It was also believed that such a program could be developed without curtailing the distribution of the valuable Transactions papers of permanent interest to the profession.

Although the TRANSACTIONS is being temporarily handled by the Publications staff, the approved publications report provides for the hiring of a non-staff, part-time editor of the new journal.

Approval was given by the AIME Board of Directors on November 18, 1957 for the following responsibility procedure for publications personnel of The Metallurgical Society: a) On matters of policy, editors shall report to and obtain guidance from the Society Publications Committee; b) On matters of administration, editors shall report to and obtain guidance from the Society Secretary.

Budget

The year 1957 was a year of transition. The budget was drawn up under old procedures for the Metals Branch. After February, 1957, the new Society was called on to provide certain increased services, and the JOURNAL OF METALS to publish additional news items about meetings, reorganization plans, adoption of bylaws, etc. It was difficult to "live within the budget."

At the close of the books on December 31, 1957, "Income Over Expenses" stood at $1,816.61. This was possible, however, because of contributions to operating expenses. The Metals Research Publications Fund contributed $36,576.00 to pay for the publication of 576 pages of Transactions papers in four supplements to JOURNAL OF METALS.

Metals Research Publications Fund

Contributions received by the Publications Fund during 1957 totaled $33,350.00. To date, contributions have been received from 84 organizations, some companies contributing three times. The status of the Fund as of December 31, 1957, is shown in the table below:

Income	
Contributions Received During 1957:	$33,350.00
Contributions Received During 1954-56:	111,325.00
Interest Accrued:	4,470.95
Total Income	$149,145.95
Expenses	
Publication of Metals Transactions Papers, 1957:	$36,576.00
Publication of Metals Transactions Papers, 1954-56:	70,120.96
Total Expenses	$106,696.96
Balance as of December 31, 1957:	$42,448.99

All income received by the Fund goes directly for the publication of scientific papers; none is used for administrative expenses.

Publication of Transactions Papers

Summarized below are data on Transactions papers published during 1957 by the three divisions of The Metallurgical Society:

Division	Number Papers and Notes	Number Pages
Extractive Metallurgy	25.5	124.75
Institute of Metals	133.5	596.50
Iron and Steel	12.0	110.75
Total, Metallurgical Society	171.0	832.00

The total of 832 pages published in 1957 is less than the 945 pages pub-

of the Secretary of The Metallurgical Society

lished in 1956, when it was felt advisable to eliminate the substantial backlog of unpublished papers, the financial resources to do so being available. As now only a "working backlog" exists, papers were published at lower rate.

During 1957, Volume 206 (Metals Branch) of AIME Transactions was published.

Other Publications

The Institute of Metals Division published Volume IV of the series on *Nuclear Metallurgy*. This volume comprised 16 papers presented at a symposium on uranium and uranium dioxide during the IMD Fall Meeting in November, 1957. As Volume I, II, and III of the series proved popular and had gone out of print, these volumes were reprinted.

Proceedings from the Conference on Deep-Drawing Steels held in Detroit, March 18-19, 1957, have been published in book form. Proceedings of the Conference on High-Temperature Materials, held in Cleveland, April 16-17, 1957, are in preparation for printing, and publication is anticipated in early 1958.

Within the Iron and Steel Division, annual volumes of Conference Proceedings are published by the National Open Hearth Steel Committee, by the Blast Furnace, Coke Oven, and Raw Materials Committee, and by the Electric Furnace Steel Committee.

The National Open Hearth Steel Committee published these books in 1957: a) *A New Look at the Nature of the Open Hearth Process* by B. M. Larsen, United States Steel Corporation, and b) Memorial volume on *Deoxidation of Steel*, commemorating the work of Dr. C. H. Herty, Jr.

Division Activities

All three divisions appointed special Bylaws Review Committees to examine their bylaws in order to meet changed conditions within their divisions and to bring conformity with the Society bylaws.

The Institute of Metals Division changed its committee structure somewhat drastically. Of particular interest is the organization of 12 additional technical committees (now a total of 18) to cover more adequately the fabrication and use of metals. It is believed that greater service to members and potential members of AIME can be given in these areas, at present not thoroughly served. These new committees are:

Corrosion Resistant Metals
Electrical and Magnetic Metals
Ferrous Metallurgy
Heat Treating
Joining
Melting and Casting
Non-Ferrous Metallurgy
Physical Metallurgy
Refractory Metals
Shaping and Forming
Structural Materials
Surface Treatment

The Institute of Metals Division has inaugurated a changed procedure for the scheduling of research papers for oral presentation at IMD Fall Meetings and AIME Annual Meetings. Programming is based on submission of abstracts received prior to a deadline date; publication of Transaction papers has become unrelated to oral presentation and vice versa. Accepted abstracts are printed and distributed prior to the meeting.

Committees

A further change in the name of the Converter Steel Committee of the Iron and Steel Division was made to Acid Converter and Basic Oxygen Steel Committee. This committee held a significant technical meeting and plant visit to A. M. Byers Company, Ambridge, Pennsylvania, on May 15, 1957.

The newly activated IMD High-Temperature Alloys Committee has sponsored an active program. Symposiums on the *Relation of Structure and High-Temperature Alloys* were held in conjunction with the IMD Fall Meeting in November, 1957. Symposiums on *Cobalt-Base Alloys* and *Wrought Alloys* took place during the 1958 AIME Annual Meeting. This Committee was instrumental in organizing the High-Temperature Materials Conference held in Cleveland in April, 1957. A second Conference will be held in Los Angeles, May 5-6, 1958.

The IMD Metal Physics Committee was reorganized into two separate committees: the Chemistry and Physics of Metals Committee, and the Semiconductors Committee. The former conducted all-day symposiums at the 1957 IMD Fall Meeting and at the 1958 AIME Annual Meeting.

The ISD Physical Chemistry of Steelmaking Committee has developed special sessions in conjunction with the 1957 National Open Hearth Steel Conference, and the Electric Furnace Steel Conference. Sessions have also been organized for the AIME Annual Meetings. This Committee is actively assisting in the organization of the Conference on *Quality Requirements of Super Duty Steels* to be held in Pittsburgh, May 5-6, 1958.

Meetings

The Extractive Metallurgy Division met nationally at the Annual Meeting of AIME in New Orleans. It scheduled seven technical sessions. The Iron and Steel Division held seven sessions at the Annual Meeting. The Institute of Metals Division held eight technical sessions. Included in these totals were a joint session of the Iron and Steel Division with the Institute of Metals on *Manufacture of Cold-Rolled Sheets*, and a joint session of Iron and Steel Division with the Extractive Metallurgy Division on *Design of Pilot Plants*. Not included in the totals were special symposiums on Powder Metallurgy and on *The Status of Government-Supported Basic Research Program in Metallurgy*.

The Society is giving thought to long-range planning of technical meetings. The Society is considering the holding of an International Conference on the Physical Chemistry of Process Metallurgy during the year 1959. The Powder Metallurgy Committee of the Institute of Metals Division is planning an International Symposium on Powder Metallurgy in cooperation with the Metal Powder Association to be held in New York, June, 1960.

Acknowledgment

Without the continued help and conscientious work by AIME members serving on committees and in other volunteer capacities, the work of The Metallurgical Society would be impossible to perform. Their work and helpful guidance is gratefully acknowledged.

The assistance rendered in raising funds for the Metals Research Publications Fund is acknowledged with thanks. Our gratitude is also due the many organizations that have contributed so generously.

Respectfully submitted,
R. W. Shearman, Secretary
The Metallurgical Society
of AIME

Corhart Refractories Company and its parent company, Corning Glass Works, announce consolidation of their refractories research and development facilities. From these combined laboratories are coming new super refractories and radically new materials designed to meet the exacting requirements of modern technology.

Corning has been engaged in refractory research and production since 1919; Corhart since 1927. The 70 years of combined experience now makes possible an accelerated program which identifies Corhart-Corning as the leaders in the refractories field.

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NEW DEVELOPMENTS IN STEELMAKING PROCESSES

Ten years ago, informed technologists would not have forecast the 2000 tpd blast furnace, external desulfurization of hot metal, open-hearth furnaces producing 35 tons per hr without the use of blown metal, electric arc furnaces competitive with open-hearth furnaces under certain conditions, rejuvenation of pneumatic steelmaking, and commercial use of continuous casting, vacuum casting, and vacuum melting.

The costs of each new process and the availability of raw materials will govern the extent to which each process becomes established.

by D. L. McBride

THE pace at which the steel industry can adopt any new process is entirely a matter of economics, primarily related to the availability and price of raw materials, the capital expenditures required for new equipment, operating costs, and the demand for steel products. Any forecast concerning the future importance of new technical developments in the manufacture of iron and steel should be tempered by a critical examination of the records of the past and the realities of the present. Perhaps, because its origin lies in antiquity, there are some who see the blast furnace as an archaic method for recovering iron from its ores. There are those who predict that the open hearth process is entering a period of decline to be replaced eventually by the electric arc furnace as the dominant steel producing method. On the other hand, the same claims are made for the oxygen pneumatic steelmaking process. Regardless of the natural enthusiastic, but perhaps biased, opinions made by proponents of new processes, it must be recognized that the economic aspects of each process, combined with the availability of raw materials, will eventually govern the extent to which a process becomes established for the manufacture of iron and steel. Table I, from statistics by the AISI[1,6,7] shows the relative expansion of the various steelmaking processes in the US in recent years.

The availability of fuels and raw materials in the US particularly favors the open hearth process and, as shown in Table II, the open hearth process is the only steelmaking method for which the minimum and maximum amounts of various metallics usable in the process completely bracket the available supply. On the other hand, if no other steelmaking processes were used, the bessemer and the oxygen pneumatic steelmaking processes would both require as a minimum more hot metal than could be supplied by existing blast furnaces, and neither of these process could consume all of the available scrap. Conversely, the electric arc furnace uses far less than the supply of hot metal and requires approximately twice as much purchased scrap as is generated. The versatility of the open hearth process with respect to raw material requirements, combined with its ability to make all grades of steel (except the highly alloyed stainless steels) makes it improbable that there can be any significant displacement of the open hearth process by other steelmaking methods as long as the present pattern persists with respect to the relative availability of hot metal and steel scrap.

D. L. McBRIDE is Director, Metallurgical Process Development, Applied Research, U. S. Steel Corp., Pittsburgh.

Raw materials

Although some of the known reserves of high-grade iron ores are approaching depletion, recent estimates by a United Nations' special committee places the world's iron-ore reserves (containing more than 35 pct iron) at 93 billion tons which, at the present rate of consumption, should last for over 300 years. Reserves in the US are somewhat less favorable than the world reserves, but domestic reserves of iron ores containing 25 to 50 pct iron can sustain American steelmaking operations at their present rate for over 200 years. In the search for new sources of iron-bearing material, processes have been developed for the recovery of high-grade iron concentrates from the hard taconite and jasper rocks containing approximately 30 pct Fe. These concentrates promise to become an important source of iron for the manufacture of steel in the US.

Unfortunately, extremely fine grinding is required to liberate the iron minerals from taconite rock; hence, it becomes necessary to agglomerate the concentrate to make it suitable for use in the blast furnace.

Although the sintering of flue dust and ore fines has been practiced for over 50 years as a secondary

operation to the blast furnace, it remained until the close of World War II merely as a convenient, but somewhat troublesome, means of recovering iron values which otherwise would constitute a disposal nuisance. The potential value of agglomerated ore burdens is now fully recognized and it has been estimated, for the industry as a whole, that 20 pct additional production can be obtained with high sinter burdens. This development means that the industry will place increasing emphasis on construction of agglomerating plants.

Blast-furnace operations

To a great extent, modern blast-furnace operation is an art, in that it is guided primarily by the past experience of the operators rather than by a thorough understanding of the blast-furnace process. Despite the lack of scientific knowledge concerning conditions within a blast furnace, intuitive judgment, based on experience, has steadily expanded the productivity of American blast furnaces but, at times of peak production, efficiency of the operation, as measured by the coke rate, has suffered.

As shown in Fig. 1, the average daily production[1] (solid line) of furnaces producing pig iron has nearly doubled since the low point in 1932 and the trend, excluding periods of reduced demand for steel, indicates that each year pig iron production has increased about 25 tons per furnace per day. Although furnace efficiency as measured by the coke rate (dashed line) has not kept pace with increased furnace productivity, there has been, however, a significant decrease in coke rate each year since 1948. The emphasis currently being placed on research on blast furnace problems promises to bring forth even more dramatic improvements in the immediate future in both furnace productivity and coke rate. In fact, several modern American blast furnaces are capable of producing 2000 tons of pig iron per day with coke rates of less than 1400 lb per ton of hot metal.

In addition to the use of beneficiated and sized burdens, there is a possibility that significant quantities of oxygen may be used to enrich the hot-air blast in iron blast furnaces. Frequent reports are received from Europe concerning the economic and production advantages to be gained from the use of an oxygen-enriched blast in ferroalloy furnaces. The reported improvement in furnace production and the saving in coke have been confirmed by experimental operation of American ferromanganese blast furnaces using an enriched blast containing up to 29 pct O_2. In view of these favorable results, it is expected that some American ferromanganese blast furnaces will be operating with oxygen-enriched blast in the near future.

The use of oxygen-enriched blast on the iron furnaces at Weirton Steel Co. over a five-year period, as reported before the AISI by J. H. Strassburger,[2] indicates that as little as 2.0 pct O_2 enrichment of the blast is accompanied by 9.5 pct increase in iron production. This may appear to be a modest amount of enrichment; nevertheless this level of enrichment will consume 150 tons of oxygen per day for a single modern blast furnace with a blowing capacity of 100,000 cfm. Thus, before oxygen enrichment becomes established as a common practice on iron blast furnaces, it will be necessary to construct oxygen plants with capacities far greater than anything available today.

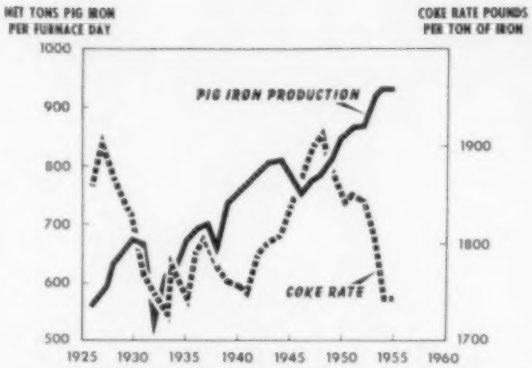


Fig. 1—Increasing pig iron production in the U. S. has not, until recently, meant decreasing coke rates.

The open-hearth process

The potential importance of the newer steelmaking processes can be placed in proper perspective by examining the current developments in the open-hearth process and its history of steady improvement and growth. As shown in Fig. 2, the capacity of American open hearth furnaces has doubled since 1938, increasing from 58,500 tons per year per furnace in 1938 to a current level of 123,000 tons per year per furnace. These values are, of course, the averages for all furnaces, but the productivity of the most modern American furnaces is even more impressive in that the best furnaces are capable of producing nearly 300,000 tons of ingots per year.

This increase in furnace productivity has been due, in part, to the abandonment of obsolete open hearth shops with small furnaces and the erection of several new modern shops with very large furnaces. Also, existing shops have increased heat size by extending the length of hearths by restricting the uptake area, and by installation of larger ladles and cranes. More important, however, there have been improvements in material handling and a greater realization of the important part that combustion practices play with respect both to furnace productivity and to erosion of refractories. All of this has led to shorter heat times so that the 12 hr elapsing from tap to tap 10 years ago is no longer considered acceptable in the face of the many open hearth shops that are currently operating at less than 10 hr tap-to-tap time. Since fuel is such an important item of cost in any metallurgical operation, the improvement in the technology of open hearth operations can be observed by examination of the trend shown in Fig. 3, covering several years, for the amount of fuel required to produce a ton of ingots. Generally, fully integrated open-hearth shops employ byproduct coke-oven gas and tar as primary fuels and supplement these with purchased fuel oil. The sharp decrease in fuel-oil consumption per ton of ingots by the steel industry during the past 10 years dramatically emphasizes the improvements in combustion practice.

Oxygen lance in the open hearth: Oxygen, both for decarburization and combustion, has played an important part in increasing the productivity of open-hearth furnaces. Although oxygen injection for decarburization is almost universally used when melting the low-carbon steel grades, the open-hearth process still falls far short of the pneumatic process with respect to the rate at which a steel bath can be decarburized. Until recently, little or no

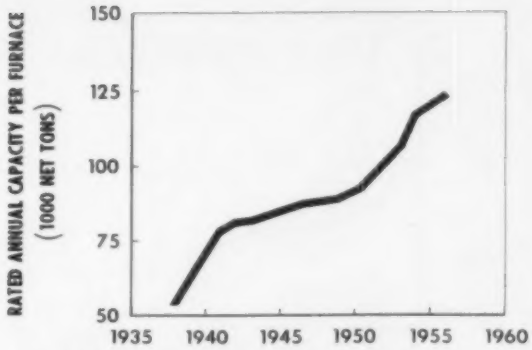


Fig. 2—Average annual capacity of open-hearth furnaces in the U. S. continues to increase.

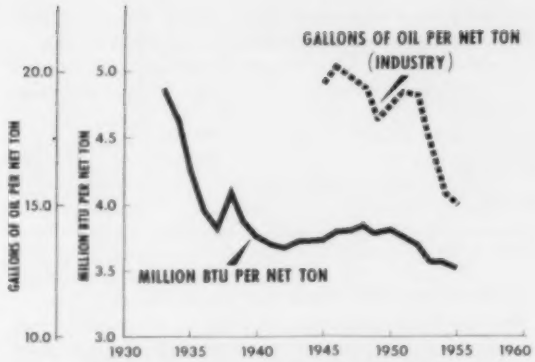


Fig. 3—Open-hearth fuel consumption in America has decreased considerably with the abandonment of obsolete shops, construction of new large-size furnaces, extension of the hearth length of existing furnaces, and closer control of combustion practice.

success attended efforts to use oxygen injection at levels above 0.25 pct C in the bath. The violent splashing of slag was considered too damaging to the refractory walls and roof of the furnace. However, this problem has been solved by inserting the oxygen lance vertically downward from the crown of the roof and dispersing the oxygen in a manner to minimize the concentrated reaction sites that result in excessive turbulence and splashing of the slag. The same mode of dispersion could be achieved with front or back wall lances, but such locations create new problems associated with charging and servicing of adjacent furnaces. Apparently the vertical oxygen roof lance can be used advantageously for decarburization at any level of carbon, provided care is taken to avoid severe splashing of the slag by proper dispersion and control of the rates of flow of the oxygen. The oxygen roof lance appears to be a very potent tool which can further increase the productivity of open-hearth furnaces.

Open hearth steel quality: Before finishing with the discussion of the open-hearth process, there is one matter concerning steel quality which must be considered, since it has a significant bearing on the future growth of any steelmaking process. As shown in Table III, the nitrogen content of basic open hearth steel is significantly lower than that obtained with any other major steelmaking practice currently in use in the US.

The effect of nitrogen on the aging characteristics of steel has been recognized for over 20 years, and research is still bringing to light new and unsuspected effects of nitrogen on the properties of steel. Unless new steelmaking processes are able to produce low-nitrogen steels, the open hearth process will remain the primary process for the large tonnages of low-carbon steels going into flat-rolled products.

All-basic open hearth furnace

The steel industry is watching with great interest the developments in the use of the all-basic open hearth furnace in trial installations at Keystone Steel and Wire, Inland Steel, Jones & Laughlin, and South Works of the U. S. Steel Corp. Most of these installations have completed only a few campaigns but, from the ten years experience with the South Works No. 10 Open Hearth Furnace, it is quite certain that production can be increased by at least 10 pct. Further experience with the newer American installations should confirm the results obtained with the South Works furnace but, regardless of the favorable increase in production, the over-all economy of the all-basic furnace remains to be verified—especially in view of the excellent production performance of many American open hearth furnaces with conventional construction.

Table I. US Steelmaking Capacity by Types of Furnaces

	1951			1957			
	No. Furnaces	Annual Capacity, 1000 Net Tons	Pct of Total Capacity	No. Furnaces	Annual Capacity, 1000 Net Tons	Pct of Total Capacity	Increased Capacity, 1000 Net Tons
Integrated Basic Open Hearth	773	82,088	78.8	771	113,392	80.6	31,304
Electric Arc	256	7,555	7.2	275	13,313	9.4	5,758
Cold-Charge Open Hearth	174	8,966	8.6	155	8,930	6.3	—36
Bessemer	41	5,621	5.4	33	4,027	2.9	—1,594
Oxygen	—	—	—	5	1,081	0.8	1,081
Total		104,230	100		140,743		36,513

Table II. Availability and Consumption of Steelmaking Raw Materials in America, (Lb Per Net Ton of Ingots)

Material	Available Supply	Open Hearth Min	Open Hearth Max	Bessemer Min	Bessemer Max	Oxygen Process Min	Oxygen Process Max	Electric Furnace Min	Electric Furnace Max
Pig iron	1340	200	2300	1850	2150	1730	2300	150	200
Iron scrap	70	0	350	0	400	0	150	0	70
Steel scrap—home	680	0	680	0	400	0	600	0	680
Steel scrap—purchased	620	0	1170	0	0	0	0	1250	1330
Ore	—	0	230	0	75	0	250	0	30
Alloy additions	—	10	100	15	30	10	30	0	1000

Table III. Nitrogen Content of Iron and Steels

	Normal Range, Pct N
Pig iron	0.002 to 0.006
Open hearth steel	0.003 to 0.006
Electric furnace rimming steel	0.005 to 0.008
Electric furnace killed steel	0.006 to 0.015
Acid bessemer steel	0.009 to 0.018

Pneumatic steelmaking

The acid bessemer process has been, until recently, the only commercially established pneumatic steelmaking processes in the US. Pneumatic steelmaking processes have many attractive features but, unfortunately, these are offset to a great extent by severe limitations. Simplicity of the operation is a distinct advantage and, with some qualification, we may also include as advantages their ability to produce low-carbon steels at high rates of production and their independence of the vagaries of the scrap market.

These qualified advantages are offset by the fact that none of the pneumatic steelmaking processes are especially suitable for the manufacture of alloy steels and carbon steels containing more than 0.25 pct C. What may, under some conditions, be considered as an advantage regarding lack of dependence on scrap as a raw material, may also be a distinct liability, since essentially all of the iron units to support the operation must be derived from ore by way of the blast furnace. In fact, the decline of the bessemer process as an important steelmaking method is closely related to the inability of the process to consume scrap in proportion to the available supply. Since about 1930, the amount of pig iron required per ton of ingots has remained fairly constant, and this, in turn, means the amount of scrap consumed by the steel industry has kept pace with the manufacture of new steel. Actually, as shown in Fig. 4,[1] rejuvenation of the acid-bessemer process as a major steelmaking method would have to be matched with additional blast furnace capacity to provide the necessary pig iron. This is also true even when oxygen or steam-oxygen mixtures are used to replace the air blast in pneumatic steelmaking, although under these conditions a moderate amount of scrap can be consumed. Other factors contributing to the decline of the acid-bessemer process have been the inability of the process to eliminate phosphorus and sulfur, and the significant pick-up of nitrogen by the metal from the air blast.

Since the end of World War II, European metallurgists and research workers have made strenuous efforts to overcome the deficiencies of the pneumatic processes and have developed new processes which appear to have solved the metallurgical problems of phosphorus and nitrogen, particularly for European practice. In addition, these processes have potential application in American steelmaking practice.

About a 100 years ago, Sir Henry Bessemer envisioned the advantages and described procedures for blowing pneumatic converters with oxygen rather than an air blast. Since about 2000 cu ft of oxygen, either from air or as pure oxygen, are required to oxidize all the metalloids contained in a ton of pig iron, it is quite obvious that the technical and operating advantages envisioned by Bessemer could not be realized until processes were developed for the manufacture of high-purity, tonnage oxygen at low cost. The progress in the last decade in the manufacture of oxygen has naturally led to fulfillment of Bessemer's early concept of the important advantages to be gained by using straight oxygen for refining pig iron in pneumatic steelmaking furnaces.

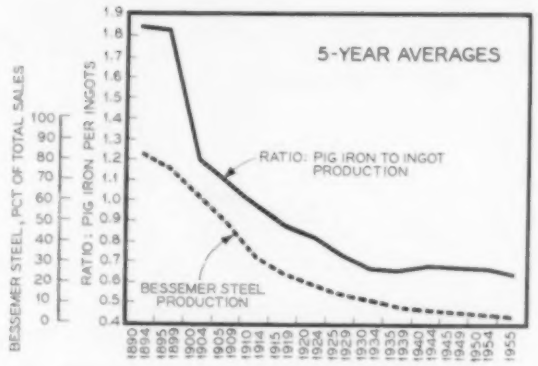

5-YEAR AVERAGES
RATIO: PIG IRON TO INGOT PRODUCTION
BESSEMER STEEL PRODUCTION
BESSEMER STEEL, PCT OF TOTAL SALES
RATIO: PIG IRON PER INGOTS

Fig. 4—Rejuvenation of the acid-bessemer process as a major steelmaking method would require almost equally matched additional blast furnace capacity.

The oxygen steelmaking practice most widely used today employs a vessel similar in appearance to the conventional bessemer converter except that the blast is introduced from the top of the vessel through a lance that extends to a few feet above the level of the metal and employs high-purity oxygen (99+ pct) as the oxidizing medium rather than air. However, oxygen steelmaking is not necessarily restricted to top-blown vessels. Oxygen steelmaking is also being practiced with bottom-blown vessels, but with this arrangement the strong exothermic effect of oxygen must be moderated by using mixtures of oxygen with steam or carbon dioxide to protect the refractory bottom and vessel lining from rapid erosion. Another arrangement of the oxygen steelmaking furnace involves blowing of oxygen into the mouth of a slightly inclined vessel while the vessel is being rotated about its longitudinal axis.

At the present time it is not possible to make any accurate forecast regarding how long the conventional acid-bessemer process will continue to operate in the US. There is reasonable assurance, however, that some existing bessemer capacity will be replaced by oxygen steelmaking furnaces. There is no indication at this time that oxygen steelmaking furnaces can economically displace existing open hearth capacity, but as new coke plant, blast furnace, and steelmaking facilities must be provided, the merits of oxygen steelmaking furnaces are receiving proper consideration.

Electric furnace

Considerable publicity attended release of a report prepared in 1953 by Battelle Memorial Institute for Bituminous Coal Research, Inc.[6] comparing the status of open hearth steelmaking with

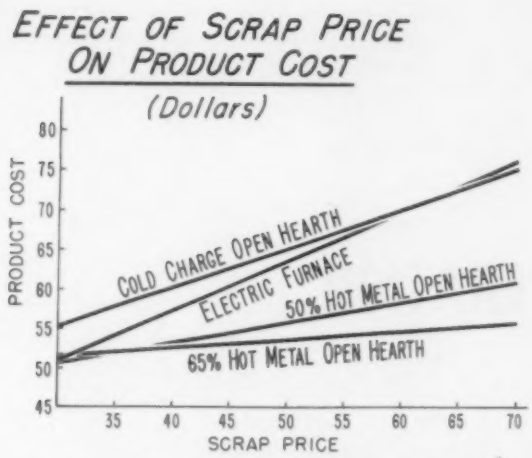


Fig. 5—The Battelle Memorial Institute's report, "Comparative Economics of Open-Hearth and Electric Furnaces for Production of Low Carbon Steel" shows the effect of scrap price on production costs of the two steelmaking techniques.

that of the electric arc process. Although emphasis has been given to the fact that the report showed electric furnace shops to be more economical than non-integrated open hearth shops, equal emphasis should be given to the data in the report showing that the situation is reversed when electric furnaces are compared with hot-metal, open-hearth operations. For example, calculations based on the data given in Table 32 and 33 of the Battelle report show the important effect of scrap prices on the relative advantage or disadvantage of electric furnaces versus cold-charge and hot-metal open-hearth furnaces. These calculations, shown in Fig. 5, indicate, in agreement with the Battelle report, that the electric-arc furnace is more economical than cold-charge, open-hearth furnaces. However, for open-hearth furnaces charged with hot metal, electric furnaces do not become competitive until the price of scrap falls below $33 per net ton, which was the cost of hot metal estimated by Battelle. Some have proposed that this situation would be altered by the use of hot metal in the electric-furnace process. From experience it is evident that the use of partial hot metal charges to replace scrap has little or no value as far as production rates are concerned, especially when using modern, fast charging, top-charged electric furnaces.[6] The sole advantage, when warranted, would be to partially replace high-priced purchased scrap with lower-cost hot metal and its attendant increased slag volume.

There is no question that electric-arc steelmaking capacity will continue to increase, but at this time there is no basis for expecting that fully integrated steel plants capable of producing 1.0 million tons per year of carbon-steel ingots will find any economic justification for replacement of present open hearth equipment with electric furnace facilities. Although capital costs are lower for construction of electric-arc furnaces than for open-hearth furnaces, this advantage is more than nullified by the high operating cost of electric-arc furnaces. Actually, the principal advantage of the electric-arc furnace is that it can produce all grades of steel, including the stainless steels and some of the super alloys.

Since the electric furnace process is largely dependent upon scrap as its source of iron units, the potential growth of electric steelmaking capacity is closely linked, at present, with the volume of scrap made available from other steelmaking processes. However, the growth potential and the economic position of electric furnace steelmaking will be placed in an entirely new perspective if current research efforts lead successfully to the development of a commercial process for the manufacture of synthetic scrap directly from iron ore.

Synthetic scrap produced by the fluidized-bed reduction, and other types of sponge-iron, would be quite suitable for use in open-hearth furnaces or even pneumatic-steelmaking processes, but it may have its greatest influence on the future of the electric furnace steelmaking capacity, since it may permit an integrated steelmaking operation with electric furnaces in the sense that ore could be used as the source of primary iron units required to sustain operations.

Automatic controls

Automatic controls in all industry are today receiving more attention and publicity than at any time in the past. The term *automation* has been coined to describe this activity, but, unfortunately, the public is unaware that automation was born with the first mechanical device invented to ease the labor of man or to improve the quality of his handicraft. The iron and steel industry, although not generally recognized as such, has been a leader in the application of mechanical devices, instrumentation, and automatic controls designed to increase the productivity of furnaces and mills, and to improve the uniformity and quality standards of the product. Though well advanced in some major areas, the steel industry has lagged in the development of mechanization and continuous, automatically controlled processing in such fields as materials handling, automatic charging of blast furnaces and steelmaking furnaces, controlled program firing of steelmaking furnaces, soaking pits, and reheating furnaces, and the automatic regulation and adjustment of primary and finishing mills.

The pace at which automatic controls and regulating devices can be applied to metallurgical processes in the steel industry depends entirely upon the amount of talent available for this work. Already some finishing mills are operating with automatic gage controls, and the first steps are being taken toward the program firing of open hearths, soaking pits, and reheating furnaces. Instrumentation and automatic control of sintering operations should be a reality in the near future. With each successful application of automatic controls to some phase of iron- and steelmaking, the imagination of metallurgists, technologists, and operators will be stimulated, and from this will result an increase in output, improved quality, and an improved degree of uniformity.

References

[1] American Iron and Steel Institute: *Annual Statistical Report.*
[2] American Iron and Steel Institute: *Yearbook*, 1956, p. 175.
[3] AIME Annual Meeting, February 1956.
[4] Battelle Memorial Institute: *Comparative Economics of Open Hearth and Electric Furnaces for Production of Low Carbon Steel.*
[5] AIME, *Electric Furnace Steel Proceedings*, 1953, vol. 11, pp. 202-219.
[6] Steel Magazine, Oct. 1, 1951, p. 128.
[7] Iron Age, Feb. 2, 1956.

HUMIDIFIED BLAST FURNACE OPERATION

Use of humidified blast is particularly valuable where practice necessitates use of Lake Superior ores, because they cannot withstand higher blast temperatures unless used in conjunction with controlled moisture in the blast. This paper describes operating characteristics of No. 5 blast furnace at Indiana Harbor with higher blast temperatures and added moisture.

by Richard J. Wilson

THE primary function of the blast furnace operator is to control the hearth temperature of the furnace and thus the percent silicon and sulfur in the hot metal.

In general the operator has two methods of controlling hearth temperature: 1) changing the blast temperature, and 2) changing the burden:coke ratio. Under former operating conditions changing the temperature of the blast was used for small variations in hearth temperature only, since it was not possible to increase the blast temperature more than 200°F. For major changes in hearth temperature, the burden:coke ratio was varied, but for this change to be effective a lapse of up to 12 hr is required, and in the meantime considerable quantities of off-grade iron can be produced. It is thus obvious that,

Lack of control of blast furnace process has resulted in a substantial loss of tonnage and quality.

Use of steam in the blast provides an additional means of controlling blast furnace operation, and it was largely on this basis that experiments with a humidified blast furnace were commenced at Indiana Harbor Works of Inland Steel Co. The amount of steam introduced into the furnace at a given time is a function of the hearth temperature, since decreasing the moisture content of the blast is the same as increasing the blast temperature.

At Inland Steel Co. the use of steam injection into the blast of No. 5 furnace was started on Feb. 6, 1957 and used almost continuously throughout the remaining months of 1957. Pertinent design characteristics of No. 5 blast furnace are a hearth diam of 25 ft 9 in. with a working volume of 39,411 cu ft, thus a working-volume-to-hearth-area ratio of 75.6. The furnace has available four stoves with a total heating surface of 931,749 cu ft.

Operations compared with identical furnace

In order to present some detail of the operating characteristics of using steam in the blast, the data was divided into periods, and wherever possible No. 5 furnace was compared with her sister furnace No. 6, even though the tonnage on the lining was 2.7 million net tons for No. 5 furnace, and only 0.8 million net tons for No. 6 furnace at the outset. Because of space limitations data is presented on the two most significant operating periods.

Period I—Feb. 6 to March 31, 1957

The burdens on No. 5 and No. 6 furnaces were identical during this period, except for normal burden cuts and additions to control the hearth temperatures.

Table I shows the operating data for the two furnaces. No. 5 furnace—on steam—produced 6.6 pct

RICHARD J. WILSON is Asst. Supt., Plant No. 2 Blast Furnaces, Inland Steel Co., East Chicago, Ind. This paper is being presented at the 1958 Blast Furnace, Coke Oven, and Raw Materials Conference, Cleveland, April 1958.

Table I. Operating Data for Blast Furnace No. 5 with Steam Compared with Identical Blast Furnace No. 6 During Same Period and with Best Previous Month for No. 5 Furnace

	Feb. 6 to March 31, 1957			Dec., 1956	
	No. 5 with Steam	No. 6	Difference, Pct	No. 5, No Steam	Difference Between Column 1 and 4, Pct
Production, tpd	1538	1443	6.6	1462	5.2
Coke Rate, lb per ton hot metal	1568	1557	0.7	1538	1.9
Wind, cfm	79,758	78,034	2.2	78,065	−2.2
Slag Vol, lb per ton hot metal	896	897	−0.1	917	−2.3
Blast Temp, °F	1386	976	42.0	1049	32.1
Top Temp, °F	286	323	−12.9	286	0
Burden: Coke Ratio	2.47	2.44		2.49	
Sinter in Burden, pct	23.2	24.4		31.6	
Sized Ore in Burden, pct	16.4	15.7		24.9	
Si in Hot Metal, pct	0.97	1.04		1.03	
S in Hot Metal, pct	0.035	0.032		0.033	
Flue Dust, lb per ton hot metal	264	215		168	
Steam, grains per cu ft	11.5	—		—	
Wind, cu ft per lb coke	46.6	49.0		49.9	
Delays, hr, min	11, 34	43, 27		0, 43	
Coke Consumed, tpd	1204	1124		1124	
Coke Carbon Consumed, tpd	1116	1042		1044	

Table II. Comparison of Driving Rates on Blast Furnaces

	Cu Ft Wind Per Lb Coke	Wind, Cfm	Coke Carbon Consumed, Tpd
No. 5 Furnace with Steam, February 6 to March 31	46.6	79,689	1116
No. 5 Furnace December, 1956	49.9	78,065	1044
No. 6 Furnace February 6 to March 31	49.0	77,582	1042

Table III. No. 5 Blast Furnace Operation with 100 Pct Sized Ore and Sinter and Humidified Blast, December 1957

Production, tpd	1506
Coke Rate, lb per ton hot metal	1437
Wind, cfm	73,146
Slag Vol, lb per ton	744
Blast Temp, °F	1419
Top Temp, °F	293
Burden: Coke Ratio	2.46
Sinter in Burden, pct	64.5
Sized Ore in Burden, pct	35.5
Si in Hot Metal, pct	1.04
S in Hot Metal, pct	0.034
Steam in Blast, grains per cu ft	16.5
Wind, cu ft per lb coke	46.8
Delays, hr, min	28, 23
Coke Consumed, tpd	1082
Coke Carbon Consumed, tpd	1005

Table IV. Blast Temperature Equivalents of Moisture

Amount of Moisture Gr per Cu Ft	Blast Temperature, °F	Difference, °F
0	1000	—
5	1112	+112
10	1224	+224
15	1336	+336
20	1448	+448
25	1560	+560
30	1672	+672

Table V. Effect of Moisture on the Sensible Heat in the Blast

Moisture, Gr per Cu Ft	Sensible Heat in Blast, BTU	Pct of Total Heat Input
0	1,888,500	24.4
5	2,179,850	28.3
10	2,459,200	31.9
20	3,033,900	39.4

more iron at a coke rate 0.7 pct higher and a slag volume slightly higher than for No. 6 furnace.

Comparison is also made between period I steam operations on furnace No. 5 and the best month of the same furnace prior to the experimental period, December 1956. The percentage of sized ore in the burden was 24.9 pct in December 1956 versus 16.4 pct in the steam period, and the percentage of sinter 31.6 pct in December 1956 versus 23.2 pct during the steam period. In spite of this advantage, production was 5.2 pct higher during the steam period. The coke rate was 1.9 pct higher, even though the slag volume was 2.3 pct less and the wind rate was 2.2 pct higher.

The reasons for the improvements on steam are:

1) Higher blast temperatures were available and used. The blast temperature was 42.0 pct higher on No. 5 furnace as compared to No. 6 furnace during the steam period—Table I—and 32.1 pct higher than No. 5 furnace during December 1956.

2) Faster driving rates were practiced when using steam. This was due not only to the fact that higher wind rates were blown, but also due to the steam itself. This can be shown by Table II.

The tons of coke carbon consumed per day were over 6.9 pct higher during the steam test than during the comparison periods. This is reflected in the wind per lb of coke; the steam period required 4.9 pct less than No. 5 furnace in December 1956, and 6.6 pct less than No. 6 furnace during period I. The cu ft of wind per lb of coke does not include the quantity of steam injected into the blast.

Operation on 100 pct Prepared Burden

During the month of December 1957 it was decided to burden No. 5 blast furnace with 100 pct sized ore and sinter. Table III shows the results of this period.

Operation during this month was outstanding. The furnace operated at a high production rate and the lowest coke rate since the injection of steam into the blast. The production was even more remarkable because it was necessary to change the small bell on this furnace during the month. Without this delay the average tonnage for the month was 1556 tpd.

The slag volume of the burden during this period was 744 lb per ton, and this contributed to the low coke rate. Comparing the slag volume in December with that of November, there was a reduction of 11.8 pct. On this basis it would be expected that there would be a reduction in coke rate of 11.8 pct × 0.4 = 4.7 pct. The December coke rate was actually 4.5 pct less than in November. Despite the fact that the 100 pct sized ore and sinter burden was only on the furnace for one month, it can be stated that the benefits attributed to the use of steam are cumulative to the benefits assigned to the use of large percentages of sized ore and sinter in the burdens.

Hearth temperature controlled by steam

The amount of steam injected into the blast of No. 5 furnace was varied between 5 and 20 grains per cu ft. The steam was varied to control the hearth temperature and to attempt to maintain a predetermined blast pressure of 20 psig. The blast temperature was maintained between 1400° and 1500°F. If the furnace required heat, the blast temperature was increased to 1500°F (if not already at that level), and the moisture injected was decreased. The reverse procedure was followed if the furnace was too hot.

The figure shows data from the period Feb. 6 to March 31, 1957 for No. 5 furnace. Hearth temperature on No. 5 furnace was controlled by varying the amount of steam used and changing the blast temperature. Let us follow a typical sequence of events that occurred during this period.

When the blast pressure began edging up to 20.5 psig, then 21 psig, the operator determined whether the temperature in the furnace was increasing or decreasing. To do this he observed the appearance of the slag, the cast analysis, and most important, the condition of the tuyeres—whether hot or cold. If he believed the furnace to be getting hot, the operator slowly increased the amount of steam injected one grain at a time, observing simultaneously the action of the blast pressure. If the operator's observation was correct, the blast pressure started to decrease. If, however, when the amount of steam introduced was increased, the blast pressure started to rise, then the furnace was becoming cold and required the operator to decrease the amount of steam.

Table VI. Effect of Moisture on Flame Temperature

Gr of Moisture per Cu Ft at Standard Conditions	Flame Temperature, °F	Flame Temperature Loss, °F
0	3893	—
5	3793	100
10	3693	200
15	3593	300
20	3493	400
25	3393	500
30	3293	600

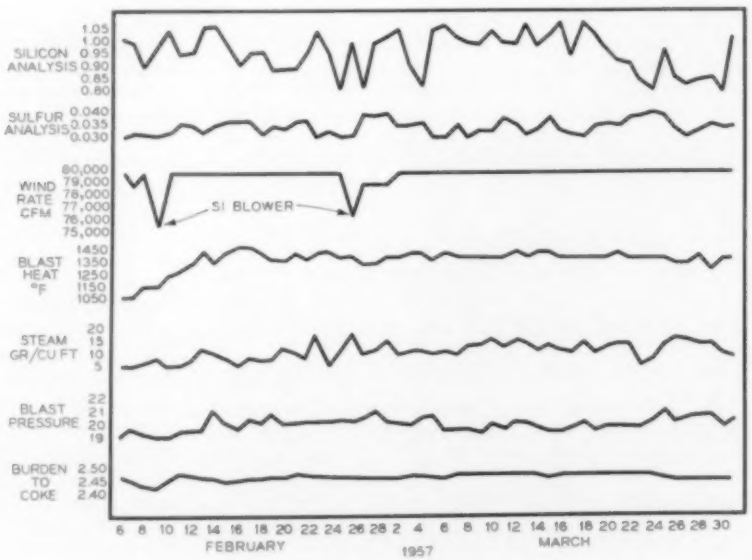
This method of controlling the amount of moisture in the blast required constant attention to be successful. The blast pressure was frequently observed and corrected by slight changes in the quantity of steam introduced. If the furnace was allowed to swing drastically, either hot or cold, adjustments in the quantity of steam introduced to the furnace did not immediately correct the situation. The furnace then began to hang, kick, and become sloppy at the tuyeres just as a furnace would do that was not using steam in the blast. However, it was possible to operate No. 5 blast furnace with an almost constant burden ratio from Feb. 21 to March 31, 1957.

Blast temperature equivalent of various levels of steam

In order to use steam successfully it is necessary to know how much heat is being added or subtracted from the furnace when the amount of steam entering the furnace is changed.

Assuming that a furnace is blowing 75,000 cfm of dry air at a blast temperature of 1000°F, the sensible heat in the blast would be:

$$75{,}000 \text{ cfm} \times 1000°\text{F} \times \frac{0.0188 \text{ Btu}}{\text{cu ft} \times °\text{F}} = 1{,}410{,}000 \text{ Btu}$$



Operation of blast furnace No. 5 at Indiana Harbor works of Inland Steel Co. from Feb. 6 to March 31, 1957—period I. The blast was humidified with an avg of about 10 grains of moisture per cu ft of wind, varying at times to as much as 20 grains. These variations generally proved adequate for controlling furnace temperatures, permitting a constant burden: coke ratio with little variation in blast temperature.

If 5 grains of moisture per cu ft of blast is added, and the volume of bosh gas produced remains constant, the following conditions exist:

Volume of Dry Air:	74,003 cfm
Lb of Moisture Added per Min:	53.57

Sensible heat in dry air:

$$74{,}003 \text{ cfm} \times 1000°\text{F} \times \frac{.0188 \text{ Btu}}{\text{cu ft} \times °\text{F}} = 1{,}391{,}256 \text{ Btu}$$

Sensible heat in moisture:

$$\frac{53.57 \text{ lb } H_2O}{\text{min}} \times 1000°\text{F} \times \frac{.49 \text{ Btu}}{\text{lb} \times °\text{F}} = 26{,}249 \text{ Btu}$$

Total sensible heat in blast = 1,417,505 Btu

In the case of using moisture in the blast, there is an additional loss of heat due to the endothermic reaction $C + H_2O \rightarrow CO + H_2$ −3096 Btu per lb H_2O. Loss of heat due to 53.57 lb H_2O per min is $53.57 \times 3096 = 165{,}853$ Btu.

Total sensible heat in blast less heat loss of steam reaction is 1,417,505 −165,853 = 1,251,652 Btu.

Difference between dry air and equivalent dry air and moisture is 1,410,000 −1,251,652 = 158,348 Btu.

Increase in sensible heat in blast required to counteract loss of heat due to the endothermic reaction is:

$$\frac{158{,}348}{141{,}750} \times 100°\text{F} = 112°\text{F}$$

Blast temperature equivalent per grain of steam is:

$$112°\text{F} \div 5 = 22.4°\text{F}$$

Table IV shows the increase in blast temperature required for various levels of steam in the blast.

The amount of moisture introduced to a blast furnace can be increased as long as the addition is compensated for by increased blast temperature. T. L. Joseph[2] showed how the sensible heat in the blast increases when additional moisture is injected into the furnace. This is shown in Table V. As the moisture content of the blast increases, the operator has a more direct control over the total heat input into the blast furnace process.

Effect of moisture additions on flame temperature

The use of steam in the blast provides another control over flame temperature. A furnace that is beginning to become hot will invariably indicate this by starting to kick. A reduction in blast temperature results in lowering the flame temperature, thus reducing the volume of combustion products under conditions in the furnace, and the kicking will stop.

A furnace that is cold or going cold will take higher blast temperatures and operate smoothly. When the furnace starts to respond to the higher blast heat or higher flame temperature, the blast pressure will increase and, unless the blast temperature is reduced, the furnace will start to kick.

The same sequence of events occurs in the blast furnace where moisture is injected into the blast. The flame temperature of a blast furnace is constantly changing even though the blast temperature and amount of steam injected remains constant. This is not strange when one considers that the blast furnace operation is not a static process but a dynamic one. The sensible heat in the raw materials entering the hearth vary, depending on the amount of preheating that occurred in the stack. Then too, the blast furnace is not charged with one raw material of uniform analysis. Heat transfer coefficients of the raw materials vary from day to day. Variations in filling order and delays in filling have an effect on the sensible heat of the raw materials entering the fusion zone. The result is that the fusion zone is changing, and the furnace may or may not react favorably to this change.

S. P. Kinney[3] described tests made on two furnaces. One of these furnaces was performing 76 pct of the reduction work between the tuyeres and the mantle. On the other furnace only 19 pct of the reduction work was being done in this zone. This represents two extremes in blast furnace operation. In the one furnace where 76 pct of the reduction work was performed in the bosh, the gas-solid contact was at a minimum. The sensible heat of the raw materials in this case was also at a minimum. On the other furnace, gas-solid contact was intimate, and the sensible heat of the raw materials entering the fusion zone would have to be greater. Consider also the amount of chemical energy dissipated in performing 76 pct of the reduction work in this zone.

L. M. Fulton[4] described the effect on the fusion zone of using steam in the blast. He also, quite clearly, described reasons for hanging, and the effect of flame temperature.

The effect on the flame temperature of various levels of moisture in the blast is shown in Table VI; lowering the flame temperature 100°F is the same as lowering the blast temperature 112°F.

The purpose of controlling the flame temperature is to maintain the temperature in the superheat zone the same. This should then maintain the fusion zone at the same level.

Summary

The use of moisture in the blast in conjunction with compensating increases in blast temperature on No. 5 blast furnace was described. The benefits attributed to the use of steam were:

1) An improvement in hearth temperature control, and
2) An increase in the driving rate of the furnace.

The result of the improved hearth temperature control and the increased driving rate was an increase in production of 5 to 7 pct, with little or no increase in the coke rate.

It was also shown that the benefits of using steam in the blast are cumulative to the use of high percentages of sinter and sized ore in the burden.

It is not expected that any advantage will be derived from the use of humidified blast unless constant and close observation of the blast furnace operation is maintained.

One of the results with which this extra vigilance will reward the operator is that he can run his furnace with a fairly constant burden, blast heat, and wind rate, and regulate the fine tuning of control with a delicate adjustment of a few grains of moisture in the blast.

References

[1] C. M. Squarcy and R. J. Wilson: *More Iron Without More Furnaces*, Regional, Technical Meeting, AISI, 1956, pp. 163-188.
[2] T. L. Joseph: *Blast Furnace Lecture*, Inland Steel Co., December, 1957.
[3] S. P. Kinney: *U.S. Bureau Mines Technical Paper 442* (1929).
[4] L. M. Fulton: *Lessons from a Hanging Blast Furnace*, AIME Blast Furnace, Coke Oven and Raw Materials Conference, 1950, p. 280.

FIRING PRACTICE: NATURAL GAS REPLACES STEAM

Two plants report on atomizing liquid fuel with natural gas rather than steam. Result: higher production and better overall operation.

Granite City Steel Co.

by J. E. Goodin

GRANITE City Steel started in June 1954 on an experimental program using high pressure natural gas to replace steam as the atomizing agent on open hearth furnaces. There are at the Granite City plant four 250-ton and three 285-ton furnaces, one of the latter of which was chosen for this project. It was equipped with a 7x7 single stage, double acting, booster compressor, driven by a 75 hp motor, capable of delivering 50,000 cu ft per hr at 250 psig, with an inlet pressure approximating 90 psig. The compressor cylinders were water-cooled. There were, in addition to the normal three-step control of the compressor, a number of safety control devices.

From the compressor, the gas was sent through a 24-in. diam by 12-ft long receiver from which it was piped to the superheater installed in the stack flue. Valves are provided so that either steam at 160 lb or natural gas at 250 lb may be sent through the superheater. This was done to keep costs at a minimum and also to make it a simple operation to change from gas to steam as the atomizing agent when necessary maintenance had to be performed on the compressor, or when gas was interrupted by extreme cold weather, at which time the gas company could not furnish gas.

Alternating steam and natural gas

For several months, the experimental program on the furnace was carried on by alternating steam and gas on a schedule of steam one week and gas the next week. Close observation was maintained on the furnace, comparing flame characteristics, melting rate, costs, etc. Even though costs per ton of steel produced were lower, due to the greater use of the cheaper fuel, the heat time at first did not improve to any great extent when using high pressure gas instead of steam. The firing rates used during this interval were as follows:

	Melt Down	After Hot Metal	Refining
Air, cfm	16,500	16,500	15,000
Oil, gal per hr	400	350	300
Gas, cu ft per hr	50,000	50,000	50,000
Furnace Pressure	0.075	0.075	0.075
Reversal Cycle, min	12	12	12

The first campaign was run from June 18 to August 10, getting 100 heats on the roof. The overall shop average was 143 heats per roof. Flame characteristics were fair, but had a tendency to float to the roof.

J. E. GOODIN is Assistant Superintendent, Granite City Steel Co., Granite City, Ill.

Using natural gas continuously

In January 1955, using natural gas as the atomizing agent continuously, experiments were begun with higher furnace pressures, maximum air input and shorter reversal cycles. During this period, the following firing schedule was used:

	Melt Down	After Metal	Refining
Air, cfm	25,000	25,000	25,000
Oil, gal per hr	350	300	275
Gas, cu ft per hr	50,000	50,000	50,000
Furnace pressure	0.15	0.15	1.15
Reversal cycle, min	6	6	3½

This was approximately 120 million BTU an hour input when melting down. Excess oxygen varied between 3 and 5 pct. During the very late stages of the heat just prior to tapping, first helpers reduced air input very slightly.

With the increased furnace pressure, a shorter, sharper flame resulted that could be controlled readily, and kept away from the roof; it melted scrap very rapidly. Maximum input of air and short reversal cycles helped to control roof temperatures to a safe value.

Immediately upon applying the above operations on this furnace, the tons per hour began to increase. The first 39 heats tapped were logged very completely on every phase of operation. The average tons per hour was 23.19, with a low of 19.14 and a high of 29.61. The shortest heat time during this period was 9 hrs 50 min from tap to tap with 1 hr delay between heats.

Application to other open hearths

After two months of successful operation on this furnace, it was decided to go ahead with the program and equip all furnaces with individual compressors. It was decided that the three large furnaces would be equipped with compressors capable of delivering 65,000 cu ft per hr and continue with 50,000 cu ft per hr for the four smaller furnaces. Compressor details for the two furnaces are as follows:

	250 Ton Furnaces	285 Ton Furnaces
Size	7 x 9	8 x 11
Maximum Pressure	250 psig	250 psig
Rpm	360	300
Induction Motor	75 hp 1760 Rpm	100 hp 1170 Rpm

Although the compressors provide 250 psig discharge, only 210 psig appears at the burner, due to pressure drop across numerous valves and small inter-connecting piping. Piping on one furnace will be enlarged to secure higher pressure and increased volume at the burner.

Tonnage raised, fuel input reduced

The records show that in a little over 18 months prior to January 1, 1956, tonnage had increased from 17.1 tons per hour to 20.5, with a drop in BTU's per ton from 4.1 million to 3.6. This was accomplished using an average of 38 pct hot metal.

During most of 1956, due to the building of a new and larger blast furnace, the shop was operated on a very low percentage of hot metal—small furnaces approximately 12 pct, large furnaces approximately 25 pct. Since September 1, we have raised the hot metal to 40 pct and have had some very good results. The highest tons per hour was 34.71 from the large furnaces and 26.40 tons per hr from the small furnaces.

At Granite City Steel, high pressure gas as an atomizing agent has been used efficiently to replace steam. The current prices of natural gas and fuel oil also make a high pressure gas for atomization economically attractive.

Empire-Reeves Steel Corp.

by V. B. Thompson

SEVEN open hearth furnaces at Empire Steel's Mansfield, Ohio plant have been converted from oil-steam to oil-natural gas firing with resultant reduction in cost, increase in production per furnace, improved product, increased fuel input, decrease in combustion products per unit of fuel, reduction in amount of fluxes needed, and a considerably hotter flame for faster melt down of cold steel. Five of these furnaces are 155 ton capacity; one, 180 ton; and one, 125 ton.

Fortunately, 200 psig gas pressure was available directly from gas company lines, otherwise compressors would have been necessary. Before the conversion, atomizing of the oil was accomplished by the injection of high pressure steam into the oil stream in the burner mixer. Replacing the endothermic steam with exothermic qualities of natural gas has meant greater heat inputs per hour and higher flame temperatures with resultant faster melt-down of the charge.

V. B. THOMPSON is Manager, Industrial Dept., Ohio Fuel Gas Co., Columbia Gas System, Inc., Mansfield, Ohio.

Once in the chamber, the atomizing gas ignites instantaneously, adding a high thermal cracking effect to the mechanical atomizing. As a result of the thorough fuel dispersion, carbon particles are liberated more quickly from the oil and raised to intense incandescence, producing a much more radiant flame. This still further speeds the transfer of heat to the charge.

Up to 90 pct natural gas

The fuel mixture is richest in natural gas during the melting period when the heat input rate must be highest: 90 pct gas and 10 pct oil. During the refining period, when the firing rate is reduced by approximately 20 pct, the proportion of natural gas is reduced to 50 pct.

The substitution of natural gas for steam results in a lower volume of combustion products per unit of fuel. Because of this, a greater fuel imput rate is possible with the existing draft, making additional blower capacity unneccessary. The result has been an increase in production of approximately 0.5 tons per hr per furnace.

The gas supplied is substantially sulfur-free, while the oil used for firing averages approximately 0.75 pct S. Sixty-five percent of the total heat imput is now sulfur-free gas; therefore, the steel is exposed to only 35 pct as much sulfur from the fuel as when oil was atomized with smaller quantities of steam. The result is lower sulfur values for the steel.

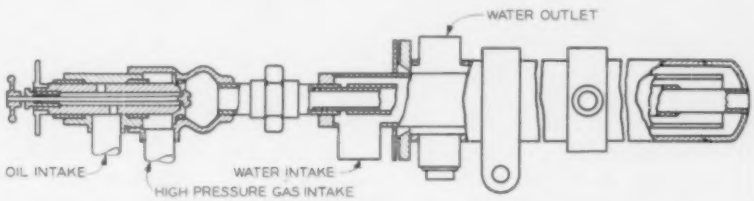
Conversion costs recovered in one month

Empire Steel tested the new method in one furnace. The results were so satisfactory that all seven furnaces were converted as soon as material could be made available. The cost of converting is so low that it was recovered in savings on the costs of approximately the first full month's operation.

The greatest reduction in costs resulted from replacing a large percentage of a fuel of higher cost per BTU—oil—with a lower priced fuel—natural gas. This saving alone amounts to 23 pct of previous fuel costs.

The decrease in oil consumption reduced the volume of oil in storage, thereby reducing capital tied up in oil inventory by more than 5 pct.

Empire Steel is working toward supplying a higher percentage of the total heat input from natural gas. By some changes in furnace design, and method of fuel input, they have already raised this proportion to 90 pct on some of their furnaces. To do this, they are introducing raw gas into a passage in the air uptake chamber and allowing this low-pressure cracked gas to enter the furnace just under the firing end of the burner. This supplies luminous carbon particles and reduces the amount of oil required for this purpose.



Crowe artillery burner for open hearth steel furnaces, as used at Empire-Reeves Steel Corp.

IRON-COKE PROCESS

The iron-coke process has been developed for the carbonization of high-volatile coal which, if carbonized by itself, would yield poor-quality, splintery coke. Metallurgical coke could be produced from this type coal by blending it with medium-volatile coal, but deposits of medium-volatile coals are limited; hence, other means are required for large-scale utilization of high-volatile coal for the production of metallurgical coke.

by H. Barking and C. Eymann

THE production and metallurgical utilization of ferruginous coke has been attempted for many decades, making use of normal coking coal, blast-furnace dust, pyrite calcines, and similar materials. However, such experiments were designed largely for the agglomeration of fine materials, and the ferruginous coke varied considerably in quality, rendering it unacceptable for blast furnace charging.

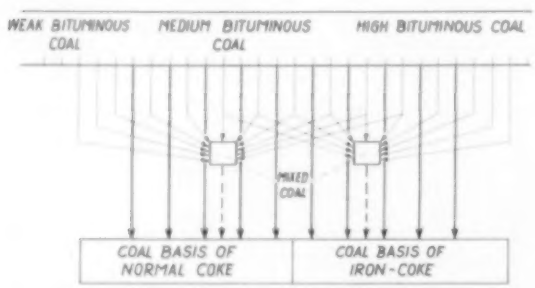


Fig. 1—High-volatile coals can be used in the production of metallurgical coke by blending with other coals, but the iron-coke process can use high-volatile coals without blending. A general enlargement of the coal basis for coke production is the result.

The new Walsum process provides a different approach. It is *not* an agglomeration technique, and only the quantity of ore necessary for the improvement of the resulting coke is added. The process is designed to produce a metallurgical coke from high-volatile coals which cannot be carbonized alone, and it will result in a general enlargement of the coal basis for the production of coke—Fig. 1.

Easily coking bituminous coals are not available in unlimited amounts everywhere; therefore, production of metallurgical coke from more plentiful high-volatile coals is vital, particularly for those countries not possessing sufficient deposits of direct coking coals.

Mineral oil additions beneficial

Metal-active admixtures, such as fine ores or blast furnace flue dust, are useful as a bonding agent for the coking mixture. However, they may be used only in limited quantities since such admixtures precipitate certain reactions in the coking mixture upon

H. BARKING and C. EYMANN are with the Bergwerksgesellschaft Walsum mbH, Walsum, Niederrhein, Germany. This paper is being presented at the 1958 Blast Furnace, Coke Oven, and Raw Materials Conference.

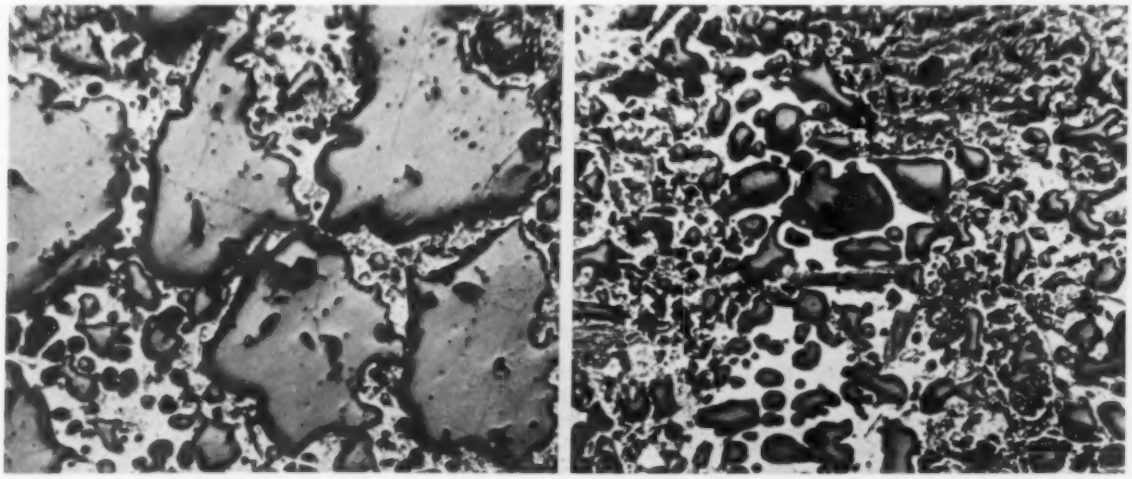


Fig. 2—Influence of magnetite upon structure of coke made from high-bituminous Virginia coal, 80 pct —2 mm with 38.5 pct volatile matter. At left, 100 pct coal; vol of pores, 69 pct; avg diam of pores 0.20 mm; after drumming, coke pieces 64 pct +40 mm and 11.2 pct —10 mm. At right, 84 pct coal, 15 pct magnetite concentrate, and 1 pct 28X mineral oil; vol of pores 53.4 pct; avg diam of pores 0.09 mm; after drumming, coke pieces 77 pct +40 mm and 8.4 pct —10 mm.

reaching temperatures between 300° and 450°C. These reactions have a softening influence on the coal, because they cause the outer surface of the coal particles to become more or less deplasticized and loose their cementation capacity, i.e., their ability to form bridges of high polymers. This deplasticizing or catalytic action of the fine iron oxides is particularly great when large portions of the metal-active material are used. But, it has been found that the addition of small quantities of mineral oil to the coking mixture can diminish the deplasticizing action to such an extent that these admixtures can be used in larger quantities.

Catalytic effects of ore additions

During the coking process, particles of coal are first softened, and then cemented with the neighboring coal particles into a porous mass. In the course of further heating, volatile matter continues to separate from this semi-coke and moves along the developing mass of coke together with vapors of bitumen set free from uncarbonized areas. The bitumens can either participate in the process of interlacing the plastic phase or are cracked at the existing hot spots. Such poylmeric interlacings and residues of cracking will cause—especially with high volatile coals—an increase of the yield of coke as compared to the yield established in the laboratory. A coal with 33 pct volatile matter and 7 pct ash, for instance, has a yield of only 67 pct crucible coke; however, in the more slowly running carbonization in a coke oven a yield of about 73 pct can be obtained.

The velocity of the reactions, which lead to the formation of coke, is normally a function of the heating velocity or the coking rate. However, addition of catalytically acting filling materials, such as iron ores, changes this relationship, for the process of polymerization on the outer surface of coal particles is influenced by these materials, thus causing another type of coke formation. The active participation of the filling materials can be varied in such a manner that coke with a desired size of pore can be obtained—Fig. 2.

Bonding and thermal conductivity

Use of substantial quantities of iron oxide admixtures is of importance to the carbonization of high-volatile coals primarily because the fine ore acts as a bonding agent and produces larger size coke. Also the bulk density of the mixture is increased, thereby resulting in the capacity of the coke-ovens being practically as high with iron coke as in the carbonization of coal itself—Table I.

The addition of fine ore to coal also improves thermal conductivity, which has a favorable effect on the rate of the reactions of cementation and coking of the glossy coal constituents. Furthermore, ore additions have a favorable effect on the reduction of stresses within the coke cake which may cause shrinkage cracks. This is a particular advantage with high-volatile or normally heavily shrinkage coals.

Uniformly distributed admixture

Besides reducing the catalytic effect of the iron-oxide admixture, another essential advantage of mineral oil additions to the coal-ore mix is that it facilitates mixing, that is making the fine ore uniformly distributed within the moist fine coal—Fig. 3. The formation of detrimental ore nests can be avoided with certainty even by small oil additions. The oil, moreover, stabilizes the mixture and prevents segregation of fractions of different specific weights which is of importance in transporting the blend to the coking plant.

In all these cases the property of the oil to distribute itself equally over the whole surface of the solid components of the coking mixture is essential. It is this same property of the oil which also reduces the catalytic effect of the fine ore upon the oxidation of high-volatile coal mixtures in storage.

German pilot operations

The iron-coke process of Barking and Eymann has been developed by the Bergwerksgesellschaft Walsum mbH at Walsum, Germany and by the Thyssensche Gas- und Wasserwerke GmbH at Duisburg-Hamborn. It is the subject of U.S. patent 2,760,855, granted in 1956.

Walsum coal used in the experimental work is classified according to the International System of Coal Classification by code number 633; thus, it resembles American high-volatile coal.

The coal is ground in such a manner that 80 pct has a grain size below 2 mm. Magnetite concentrate has been used. The moist fine coal and the moist magnetite concentrate are proportioned by a belt-

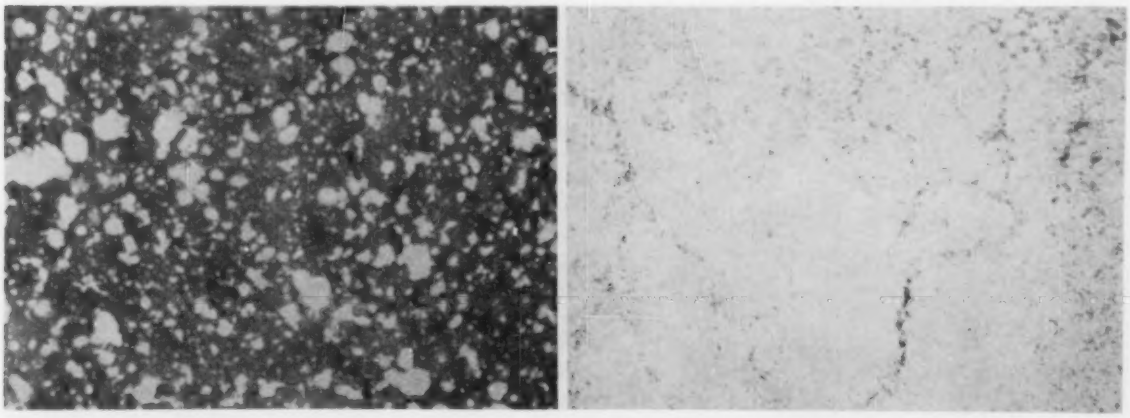


Fig. 3—X-ray photographs of mixtures of coal, ore, and oil. At left, sample carefully mixed by shovel over cone of repose. At right, sample from continuous mixer made up of 80 pct moist fine coal, 80 pct —2 mm; 19.5 pct moist magnetite, 100 pct —1 mm; and 0.5 pct mineral oil.

weightometer, then fuel oil is added, and the blend is homogenized in a continuous mixer. X-ray photographs showed that a uniform coke structure is obtained.

The mixture, consisting of 80 pct high-volatile coal, 20 pct magnetite concentrate, and some oil, shows more shrinkage than medium-volatile coal during carbonization. Furthermore, the iron-coke thus produced consists of large pieces. The coke cake, therefore, parts further away from the coke-oven walls than normal coke and can be pushed out more easily. During the tests, walls of the oven remained unaffected.

Iron coke in other countries

Results similar to the German experiments have been reported by a coking plant of the Republic Steel Corp., where about 50,000 tons of iron coke with 35 pct Fe has been produced from high-volatile coal and taconite concentrate. The same has been reported by a Soviet coking plant which has produced 400,000 tons of iron coke—7.5 pct Fe—with blast-furnace flue dust. During World War II the Yawata Iron & Steel Co., Fukuoka, Japan, produced 200,000 tons of similar coke from a 23 pct ash coal and flue dust. In all of these cases mixtures free of oil were used which tends to promote the formation of ore nests, especially when coarse ore and coarse coal are used.

These experiments demonstrated that magnetite concentrate, taconite concentrate, and blast-furnace flue dust did not attack the walls of the coking chamber after an operation of several months.

Blast furnace operations

In the German experimental operation, the iron coke is first subjected to a screening operation. The +40 mm fraction, which amounts to only 15 pct of the coke, is charged directly into the blast furnace. The fines are screened a second time, the −10 mm being used in the sintering plant, and the fraction between 10 and 40 mm being charged into the blast furnace.

Samples obtained from the level of the tuyeres have shown that no reduction in the strength of the iron-coke takes place during the dropping of the charge in the blast furnace. Tests have proven the metallurgical suitability of the iron coke in blast furnace burden, but the optimum quantity of iron in the mixture is still an open question.

Economics of the process

While the heat consumption in coke ovens is higher for iron coke, this is compensated for by the larger output of rich gas which is a result of the reduction of ore and of the cracking of oil.

The utilization of high-volatile coals has an advantage in that sintering of fine ores becomes unnecessary. Furthermore, because of the prereduction of the ore in the coke ovens, the consumption of coke in the blast furnace can be decreased.

The iron-coke process has many advantages in the utilization of raw materials. Particularly noteworthy with the Walsum process is that it is independent of the degree of volatility of the coal. It should also be pointed out that extremely fine ores and dusts, which are not well suited for normal sintering operations, can be used in the production of iron coke. X-ray studies have shown that the iron coke produced on the basis of the above process is homogeneous and does not show nests of ore.

The experiments carried out on the production of iron coke have been successful and will be pursued further with regard to the possibilities of producing different kinds of pig iron.

Table I. Capacity of the Coking Chamber, Performance in Kg Fine Coal Per Cu M Coking Space

Magnetite—Concentrate in Mixture, Pct	Total—Capacity (Coal, Ore, Oil) Kg per Cu M	Portion of Fine Coal Grading : 80 Pct <2 Mm Moisture : 10 Pct Kg per Cu M, Approx.	Portion of Magnetite—Concentrate Grading : 100 Pct <1 Mm Moisture : 6 Pct Kg per Cu M	Portion of Mineral—Oil, Kg per Cu M
0	750	750	0	0
15	915	770	135	10
20	940	740	190	10

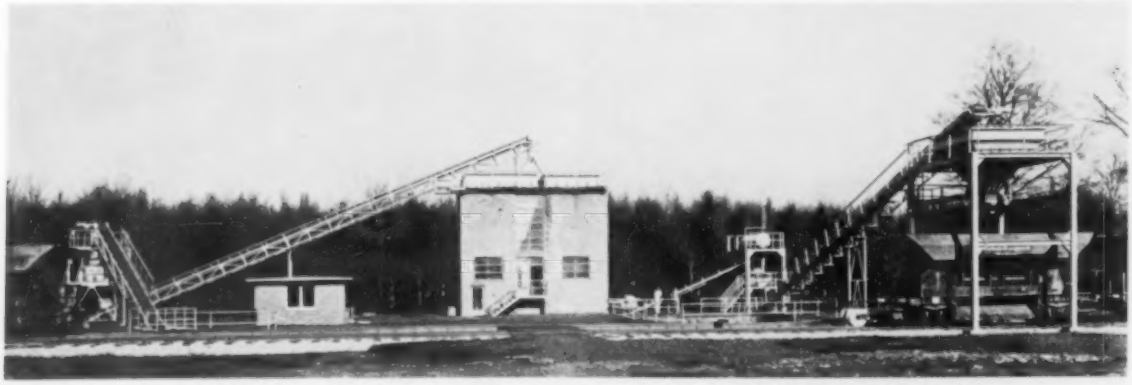


Fig. 4—Installation for coal grinding and weighing and mixing of ore, coal, and mineral oil at Walsum, Germany.

EXPANSION ALLOWANCE IN BASIC OPEN HEARTH PORT ENDS

Emphasizing the importance of proper expansion allowance, type of hangar, and sealing of joints as an aid to refractory life.

by L. L. Wells, Jr., and T. P. Greaney

ANYONE associated with the design, construction, and operation of open hearth furnaces is familiar with the fact that expansion allowances within the brickwork or between the brick and the binding are an essential part of the furnace. Equally well known are some of the difficulties which can be experienced from the lack of proper expansion allowance. Distortion or rupture of furnace binding members is not uncommon. Occasionally, structural or pinch spalling of refractories is observed. Less frequently, severe buckling of refractories may take place. Too much expansion can result in a loosely built furnace which may be costly to operate because of air infiltration, or in failure of refractories caused by supporting steel being destroyed by stingers of flame.

Determination of the proper expansion allowances is not necessarily a simple matter. Most well-known references on refractories give the thermal expansion characteristics of the various materials which can be used. But because of widely varying service applications, only generalized rules for expansion allowances are offered. For example, Norton[1] states that "all except the smallest refractory structures must have allowance made for expansion on heating. Considerable experience is necessary to know how many and what size expansion joints are to be used, but it is better to allow a little too much than not enough".

Over the years, the experience of which Norton speaks has been developed by careful observations of the behavior of refractories in actual service. This information, supplemented with laboratory data, leads to the refinements as practiced today. As might be expected, however, this knowledge does not remain static, because as changes in the quality of refractories or service conditions take place, expansion characteristics may be effected to the extent that brick-laying technique must be revised.

L. L. WELLS, JR., and T. P. GREANEY are Mason Supt. and Asst. to the Mason Supt., respectively, at the South Works, U. S. Steel Corp. Paper presented at the 1958 Open Hearth Steel Conference, Cleveland, April 1958.

Problems of basic brick

In recent years, substitution of basic brick for silica and fireclay construction has been accelerated. The typical open hearth furnace of today not only has basic front and back-walls, hearth, port end, and sidewalls, but also basic uptakes. Most furnaces in the U. S. still retain silica brick in the main and port roofs, although there are now a significant number of plants conducting experimental runs with the so-called *all-basic furnace*.

The chief advantage of basic brick is their ability to withstand higher temperatures than either silica or fireclay refractories. They possess inherent disadvantages in that they have comparatively poor load bearing ability at operating temperatures, and they are costly. To offset their cost, the usual practice is to limit their use to the hottest portions of the furnace. They are usually suspended in place by means of external supporting steelwork to offset their inability to bear loads.

More than ten years ago, the South Works plant of the U. S. Steel Corp. began a program of convert-

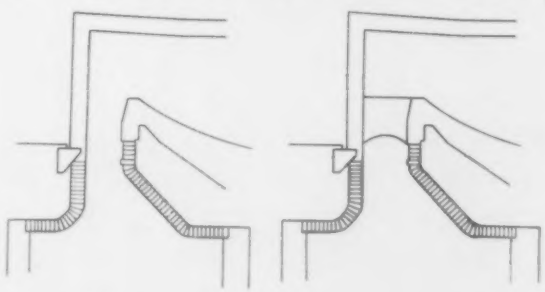


Fig. 1—Construction of open-hearth uptakes, typical of current practice. Single uptake furnace at left; double uptake furnace at right.

ing some of its furnaces to suspended basic brick construction in port ends. Since this time, one furnace has been operated continuously as an *all basic* furnace. It is the purpose of this paper to relate some of the observations which have contributed to our experience with suspended basic construction.

Fig. 1 shows the construction of open hearth furnace uptakes which are typical of current practice. It is with this portion of the furnace that we will concern ourselves.

Failures in early installations

Some early installations of suspended uptakes resulted in premature failures, seemingly erratic in nature. The question was immediately asked whether the failures were caused by inadequacies of the basic refractories, by improper installation, or by faulty design of the supporting structural work. In several instances nose sections collapsed with a life of only 200 heats. In other instances, where campaigns of 400 or more heats were obtained, the refractories showed only moderate erosion with 9 to 10 in. of the original 12 to 15 in. brick still remaining. However, stability of the construction was not reliable, because the brick were cracked either near the mid point or at the hanger socket in enough instances that they could not be relied upon to carry through another campaign.

The type of brick employed in the original installations were unfired, chemically bonded, steel encased, 70 pct magnesite shapes, having a hanger socket formed with a steel clip. Expansion joints were provided by inserting a corrugated steel plate in the vertical joint between every sixth brick. This calculated to approximately 2.2 pct, which, according to the best advice available at the time, was more than adequate, as shown by the thermal expansion data in Fig. 2.

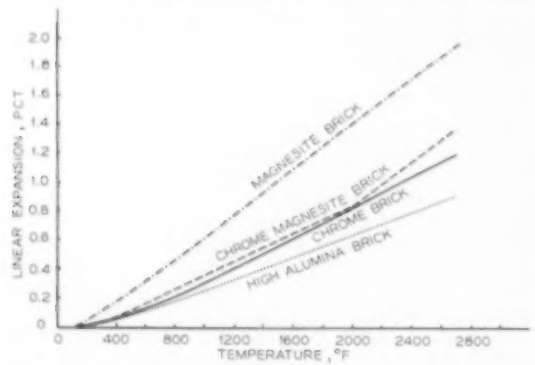


Fig. 2—Reversible thermal expansion of various refractories: magnesite, chrome-magnesite, chrome, and high-alumina brick.

Fig. 3—Appearance of magnesite brick after campaigns ranging from 300 to 700 heats. Cause for cracking concluded to be due to heat sufficient to destroy chemical bond, but insufficient to develop ceramic bond.

After campaigns ranging from 300 to 700 heats, the used brick would have an appearance similar to Fig. 3. It was concluded that cause for the cracking was due to the heat being great enough to destroy the chemical bond, but not sufficient to develop a ceramic bond. Accumulations of dust often covered the steel socket clip and contributed to its failure through oxidation. It should be noted that a major portion of the original 15 in. thickness still remained, indicating that substantially increased life could be obtained if the strength or stability of the construction could be improved. As further evidence, it should be pointed out that these characteristics were more pronounced on the nose sections of the construction where the load on the refractories was highest.

Following these observations, it was decided to overcome the failure of the chemical bond by installing fired rather than chemically bonded brick. As the fired brick are made only with a deep-hanger socket, the steel clip was eliminated also. These brick were installed with steel casings and approximately the same expansion allowance as before. Following campaigns of about the same length, close examination showed the fired brick to have failed in a manner similar to the ones described above. The brick still retained a major portion of their original length, but continued to exhibit fractures either at the hanger socket or midway between the socket and the hot face.

Because no solution for the failure by cracking was found, it was decided that rather than try for a life of more than one campaign with 15 in. brick, it would be more economical to use the less costly 12 in. brick and assume replacement at the end of one 400 heat campaign. Since there was no apparent advantage to the fired brick, the chemically bonded brick was chosen. The deep socket feature, however, was retained. Again, no change in expansion allowance was made. These installations gave no significant improvement in life.

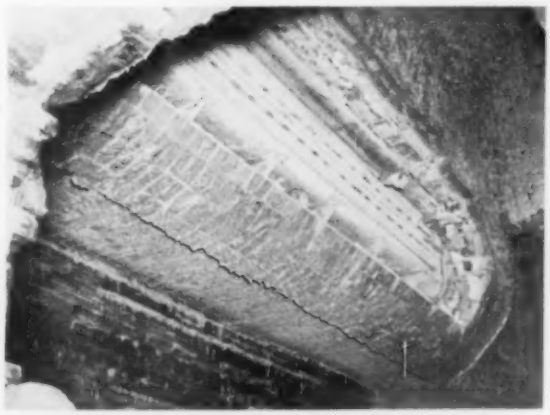


Fig. 4—Failure of suspended end-construction on 220-ton open hearth emanated from the center of the uptakes and extended toward each side wall.

Fig. 5—Uptake construction with one corrugated plate in the vertical joint between every second brick to give a calculated overall allowance of approximately 7 pct.

Experience with larger furnaces

Until that time, experience was limited to furnaces having a capacity of 130 tons, with relatively small dimensions. Two additional furnaces, having 220 ton capacities, with substantially larger uptake dimensions, were converted to suspended basic construction. The brick chosen were as described above, with the exception that the 15 in. size brick predominated. Expansion allowances remained about the same. In fact, little thought was given toward increased expansion allowances, as air infiltration studies, conducted during this period, caused us to focus attention on the quality of the brick-laying job from the standpoint of minimizing air infiltration and improving furnace performance.

These installations resulted in several failures, one of which is shown in Fig. 4. As indicated in the photograph, failure emanated from the center of the uptakes and extended toward each side wall. Failures of both the bridgewall side and endwall side occurred, although not necessarily simultaneously.

The failures seemed to occur on heating up the furnace immediately after having taken it down during mid-campaign for a new roof. In analyzing for causes, a thorough check was made of supporting steelwork, casting design, and refractories. It was failures of this type which gave us evidence that the problem included lack of sufficient expansion allowances. Remnants of brick were more than just cracked, they were crushed. Supporting castings were fractured. Some weldments holding the castings were broken. Metallurgical examination and physical tests of the castings, and engineering checks of the supporting structural members gave additional evidence that the failure must be caused, at least in part, by internal stresses set up by expansion. It should be noted, however, that a direct tie-in of brick supporting members with charging floor or building structural members also could have contributed to the failure. To eliminate this possibility all structural members from which the brick are suspended were examined and clearances increased between charging floor and building structural members to assure that floor loadings and vibrations could not be transferred to the brick work.

Increased expansion allowance

Immediately following this experience, it was agreed to provide additional expansion allowance by inserting corrugated expansion plates every fourth brick, instead of every sixth brick as formerly. This was calculated to increase the expansion to 4.4 pct in approximately two thirds of the brickwork on either side of the uptake centerline on both

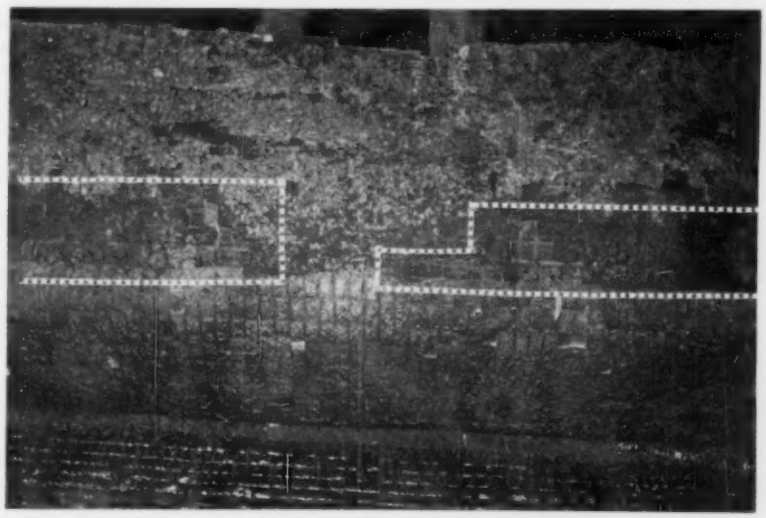


Fig. 6—Condition in uptake after one campaign. The outlined areas show where pinch spalling occurred, indicating that optimum expansion allowance-strength relationship has not yet been reached.

the bridgewall and endwall sides. Additional expansion allowance was provided by placing compressible insulation material between the outer brickwalls and the furnace binding.

Concurrent with these changes, the trials of various refractories in the all-basic furnace indicated that the most consistent results were being obtained with internally plated brick having a composition approximating 60 pct chrome ore and 40 pct MgO. Further development of the internal plate idea by a supplier included imbedding a *U* shaped steel plate within the brick in such a manner that the steel was continuous around the hanger socket. These were provided for the tile forming the nose suspension, which bears the maximum load.

It is realized that the changed composition of the brick created a second variable which would tend to complicate evaluation of the effect of increased expansion allowances. It may be observed here also that the inclusion of additional steel in the form of the internal plates and the corrugated expansion joints in themselves created need for additional expansion allowance. This may very well account for the fact that on later campaigns of these same furnaces, observations dictated a further increase in expansion allowances to a maximum of one corrugated plate in the vertical joint between every second brick in the midspan of noses of chillwalls, endwalls, and fantails, which calculated to an overall allowance of approximately 7 pct.

Photographs of typical *before* and *after* views depicting results of this most recent practice are shown in Fig. 5 and 6. In Fig. 6, the outlined areas show where pinch spalling is still occurring, indicating that the optimum expansion allowance-strength relationship has not yet been reached. A study reviewing our experience over the entire history of these two furnaces is shown in Fig. 7, and indicates, without question, that the steps taken have contributed to reduced failures and lower refractory consumption.

While this discussion has dealt primarily with experiences in suspended basic construction in furnace uptakes, some mention should be made of the role of high-alumina brick in these areas. The high cost of basic brick prompted the trial of 60 pct alumina brick in the lower zone of a chillwall. The success of this installation resulted in the use of 60 pct alumina brick in the lower zones of suspended uptakes

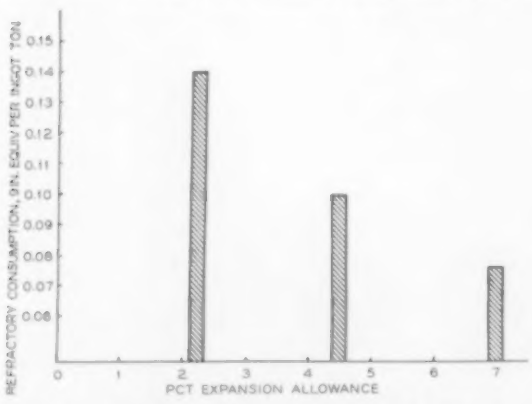


Fig. 7—Consumption of suspended refractories compared with expansion allowance as experienced on two furnaces at South works, U. S. Steel Corp. Steps taken to increase expansion allowance have contributed to lower refractory consumption.

in most furnaces. This was gradually extended so that at the present time, high-alumina brick comprise approximately 40 pct and 70 pct of the suspended brickwork under the endwalls and chillwalls, respectively, in a typical extended hearth furnace. In the zones of high-alumina brick, the corrugated metal sheets are eliminated, and full troweled joints of high temperature, heat setting mortar are used.

Discussion and summary

In considering expansion allowances necessary for chemically bonded, metal encased, chrome-magnesite brick, the following factors must be considered:

1) Chemically bonded brick develop a plane of weakness where the temperature is sufficient to burn out the chemical bond yet not high enough to form a ceramic bond; metal encased brick were developed to minimze this disadvantage;

2) The use of metal encased brick having both internal and external plates present another variable; Snow, Berry and Allen[2] have reported the oxidation of these plates in service to three times their normal thickness;

3) Rigby[3] reports that the iron-oxide impregnated hot face of the brick has a higher coefficient of expansion than the unaltered portion of the brick; fluctuations in uptake temperature as reported by Carney, Oravec, and Van Meter[4] can result in differential stresses which can shear off the hot face of the brick; and

4) The absorption of iron oxide by chrome-magnesite brick causes growth of the hot face. This has been explained in many articles as a result of solid solution between magnetite and intermediate spinels.

We have seen that the reversible thermal expansion of chrome-magnesite brick at operating temperatures is in the order of 1 pct. The factors listed above would suggest that additional expansion allowance is necessary to reduce or minimize the effects of increased stresses. On the other hand, several authors,[5-6] recommend somewhat less than the maximum theoretical expansion allowance, especially in all-basic suspended roofs. It would appear that the theory behind this approach is to maintain adequate pressure on the brick and to maintain proper contour of the arch. In suspended uptakes, where the design allows no keying action, would it not be advisable to increase the expansion allowance and alleviate the stresses peculiar to chrome magnesite brick? Our approach to the problem has been in this direction.

It is stressed that other plants, having suspensions of different designs, refractory compositions, and operating conditions may require substantially different allowances than have been reported here. We are by no means satisfied that our objective has been reached, although the results to date have been encouraging. Continued experimenting will be necessary to determine the optimum value for expansion relief.

References

[1] F. H. Norton: *Refractories*, McGraw-Hill, New York, 1949.

[2] R. B. Snow, T. F. Berry, and W. C. Allen: *Chemical Changes in Basic Brick During Service*, Journal of American Ceramic Society, No. 33, 1950, vol. 4, p. 127.

[3] G. R. Rigby: *Properties of Basic Raw Materials and Bricks*, The Iron and Steel Institute Special Report No. 46, The All-Basic Open Hearth Furnace, 1952.

[4] D. J. Carney, J. J. Oravec, and E. Van Meter: *Some Factors Affecting Open Hearth Performance*, AIME Open Hearth Proceedings, 1954, vol. 37, pp. 13-41.

[5] J. H. Chesters and J. MacKenzie: *A Critical Analysis of the Results of All-Basic Open Hearth Furnace Trials*, The Iron and Steel Institute Special Report No. 46, The All-Basic Open Hearth Furnace, 1952.

[6] A. K. Moore: *Progress Report—Basic Brick Construction*, AIME Open Hearth Proc., 1946, vol. 29, pp. 262-264.

NEW DRAWING PROCESS ELIMINATES HEAT TREATING FOR STRONG PARTS

How? Proper choice of steel grade and process conditions develop the properties previously available only through heat treating, which is thus eliminated, as well as cleaning, straightening, and finish grinding.

by E. S. Nachtman and E. B. Moore

COLD drawn steel bars are specified when closer dimensional tolerances, and superior surface finish, machinability, and strength properties than those obtainable by hot rolling or extrusion are required.

There has been a continuing interest in the improvement of the mechanical properties of this product. Early experience indicated that the tensile strength of hot-rolled bars would be increased by cold drawing. Later it was discovered that if cold drawing were followed by stress relieving, higher yield strengths and lower residual stresses resulted. Still later, another significant advance was made in the art by development of a tandem die-drawing method for eliminating cracking of steel bars which might result from heavy reductions in diameter[1]. This in turn made practicable a process of abnormally heavy drafting followed by stress relieving which provides products having a combination of desirable properties including relatively high yield strength[2].

A further development in the drawing of steel bars is described here, namely drawing at preselected temperatures between 200° and 1200°F. Little previous work has been carried out along these lines. Laboratory experiments on working steels at elevated temperatures have been reported[3,4]; however, in these cases either different working techniques were used or different materials were investigated.

E. S. NACHTMAN and E. B. MOORE are Director of Research and Development Engineer, respectively, LaSalle Steel Co., Hammond, Indiana.

This investigation was beset by unique problems of lubrication, die life, temperature control, and product uniformity, some of which are a direct result of the high temperatures and pressures occurring in the die during deformation. Of course, these problems had to be solved to make the process commercially practical.

Elevated temperature drawing produces a bar product with all the advantages previously mentioned in connection with cold finishing, along with two significant added features: strength properties are appreciably higher, and a uniformity of structure and quality is achieved not heretofore commercially available.

Parts formerly made from heat-treated alloy steels are now successfully produced from carbon steel processed by elevated temperature drawing. Productivity and tool life are increased, while the necessary strength properties are maintained. This possibility of eliminating heat treating and the attendant cleaning, straightening, cracking, inspection, etc., which may follow suggests that substantial cost savings are possible.

Apart from the reduced cost of material and processing, conservation of strategic alloy elements is also a factor to be borne in mind.

Standard AISI grades used

The materials used in this investigation were AISI steels having the usual hot-rolled structure consisting of ferrite and lamellar pearlite. Their ladle analyses are given in Table I.

Bars, as received in the hot rolled conditions, were descaled by pickling in dilute sulfuric acid.

Figures 1-4: Effect of drawing temperature on basic mechanical properties.

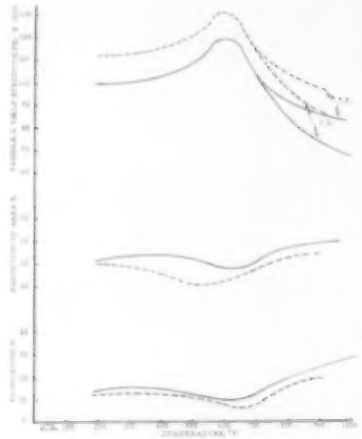


Fig. 1—C-1018 hot-rolled ¾-in. steel. Reduction: solid line, 17.2 pct, dotted line, 30.8 pct.

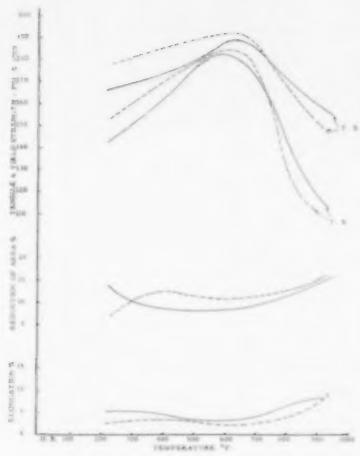


Fig. 2—C-1080 hot-rolled 9/16-in. steel. Reduction: solid line, 15.7 pct, dotted line, 22.0 pct.

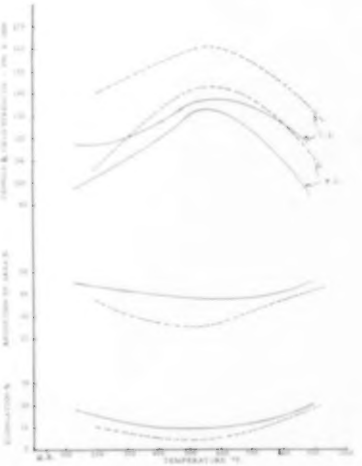


Fig. 3—C-1144 hot-rolled ⅝-in. steel. Reduction: solid line, 5.0 pct, dotted line, 30.0 pct.

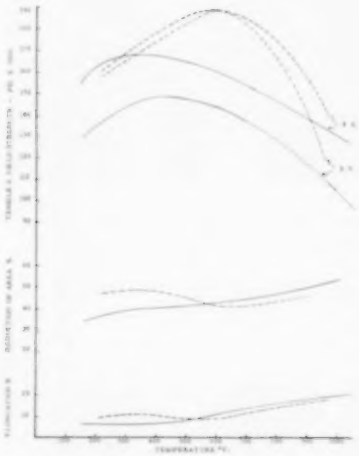


Fig. 4—4140 hot-rolled ⅝-in. steel. Reduction: solid line, 5.0 pct, dotted line, 19.9 pct.

After preheating in a resistance-type electric furnace, the bars were coated with lubricant and given a single draft through a carbide die. Several lubricants, such as graphite, soap, sulfonated grease, and molybdenum sulfide were evaluated. Of these, powdered molybdenum sulfide was found to be the most satisfactory. Immediately before drawing, it was spread by hand over the surface of the bar. Bars were then drawn at the rate of approximately 10 ft per min on a drawbench of 30,000 lb capacity.

Temperatures, as shown on the graphs, were measured by a surface pyrometer as the bars emerged from the die. This was done in order to take into account the heat gain from deformation work and friction, as well as the simultaneous heat loss due to radiation and contact with the die and lubricant. In general, normal cold drawing may increase the bar temperature up to as high as 250°F.

The cold drawn, stress relieved bars used for comparison purposes were taken from the same heat of steel and were cold drawn at room temperature followed by heating to various temperatures in an electric furnace.

Unless otherwise stated, the following conditions apply to all tests reported: 1) Tensile specimens were machined from the bar in the longitudinal direction; 2) Impact tests were made on V-Notch Izod specimens also cut in the longitudinal direction, each value being an average of three tests; 3) Yield strength values were measured at 0.2 pct offset; and 4) All tests were performed at room temperature.

Effects of drawing temperature and draft

The AISI grades C-1018, C-1144, C-1080, and 4140 were drawn at temperatures up to 1200°F. In order to evaluate the spread in properties to be expected from heat to heat of the same specification, several heats of both C-1144 and 4140 were investigated. The effect of the amount of deformation was obtained by using two different drafts in each case.

Fig. 1 to 4 summarize the results obtained from the tensile tests. The tensile and yield strengths increase to a maximum in the temperature range of approximately 500° to 600°F. Elongation and reduction of area values reach a minimum in the same temperature interval.

As could be expected, increasing drafts result in

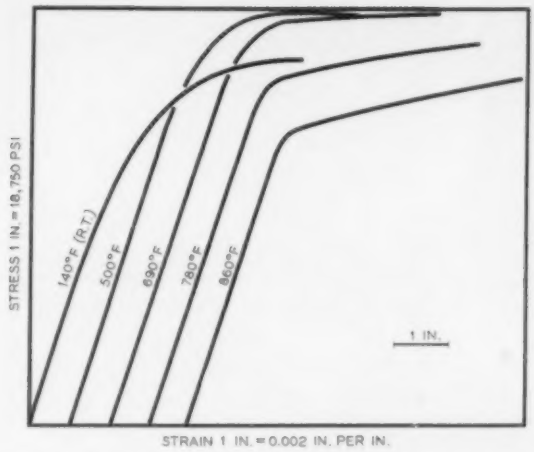


Fig. 5—Effect of drawing at elevated temperatures on the shape of the stress-strain curve. Reduction was 7.2 pct to a final diam of 27/32-in.; steel used was C-1144.

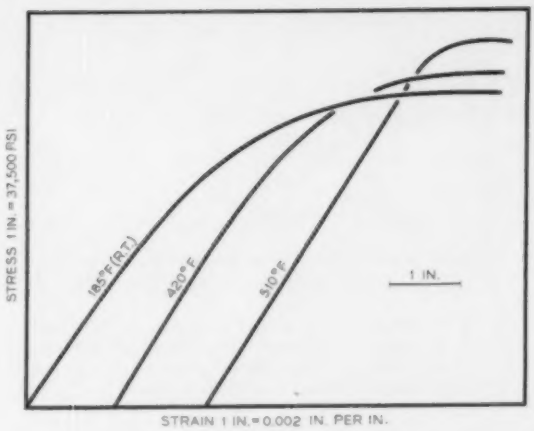


Fig. 6—Same as in Fig. 5, but reduction was 19 pct to a final diam of 9/16 in.; and the steel used was 4140.

higher strength levels for any given temperature. It seems, however, that there is a certain minimum reduction required to fully develop the effect on strength properties of drawing at elevated temperatures. This minimum varies with composition. For example, 4140—Fig. 4—given a 5 pct draft at elevated temperatures shows an increase in tensile strength of 8000 psi (5 pct) over the same material drawn at room temperature. With a 20 pct reduction the above difference increases to 25,000 psi (15 pct) which would indicate optimum results are achieved at reductions well over 5 pct. However, in the case of C-1144, 5 and 30 pct reduction result in essentially the same percentage increase, indicating in this case that the major strengthening effect has occurred even with a reduction of 5 pct or less.

It appears that increasing drafts tend to shift the temperature at which maximum strength is developed toward somewhat higher temperatures. It is also evident that proportional increase of strength with increasing draft does not occur.

Broadly speaking, the draft taken at room temperature would have to be doubled in order to obtain the increase in strength equivalent to that resulting from elevated temperature drawing.

The percentage increase in strength achieved by drawing at an elevated temperature seems to be substantially independent of carbon content within the range of steels examined.

Elongation and reduction of area values decrease with increasing carbon content. For equivalent reductions and strength levels, the alloy steel 4140 has the best ductility as measured by elongation and reduction of area.

The yield strength of all steels investigated increased from 12 to 35 pct, depending upon percent reduction and drawing temperature. In Figs. 5 and 6, the pronounced effect on the shape of the stress-strain curve of drawing at elevated temperatures is illustrated. The room temperature curves (140° and 185°F respectively) have a rounded shape typical of cold drawn steels. As the temperature of drawing increases, the proportional limit is increased noticeably.

The normal decrease of impact fracture energy associated with cold drawing is made more prominent by deformation within a certain range of elevated temperatures. Significantly, however, the maximum strength and minimum impact properties do not occur at the same temperature. In the commercially important carbon steels the dip on the impact curve is confined to a narrow range of temperatures, whereas from the viewpoint of tensile properties the choice of drawing temperature is quite broad. It is, therefore, possible to choose a temperature for drawing at which a combination of high strength and good impact values is secured.

Cold drawing and elevated temperature drawing compared

The relative effects of cold drawing, followed by stress relieving and drawing at elevated temperatures, are shown in Fig. 8. Both processes were carried out with the same draft using bars of C-1144. The effect on tensile strength of stress relieving cold drawn bars is slight. Elevated temperature drawing, on the other hand, results in a marked increase. The yield strength of elevated,

Table I. Chemical Composition of Steels in Experiments

Grade	C	Mn	P	S	Si	Cr	Mo
C1018	0.18	0.88	0.015	0.037	0.06		
C1080	0.86	0.79	0.010	0.031	0.20		
C1144	0.44	1.52	0.018	0.310	0.29		
C1144	0.45	1.51	0.018	0.280	0.22		
C1144	0.45	1.56	0.018	0.314	0.24		
C1144	0.42	1.53	0.017	0.280	0.20		
4140	0.42	0.87	0.016	0.026	0.29	0.87	0.20
4140	0.43	0.88	0.018	0.020	0.26	0.86	0.18

Table II. Mechanical Properties of Hot Rolled Steels Before Drawing

Grade	Tensile Strength, Psi	Yield Strength, Psi	Elongation, 1⅜ In., Pct	Reduction of Area, Pct
C1018	68,375	46,875	36.0	67.9
C1080	144,500	76,000	12.5	17.0
C1144	113,500	76,250	23.0	45.3
4140	146,250	102,000	17.5	48.5
4140	140,000	105,750	15.0	42.8

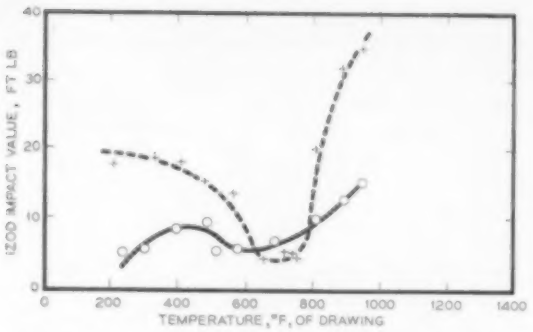


Fig. 7—A comparison of impact properties of two steels drawn at room and elevated temperatures. Dotted line: C-1144 steel reduced 21.6 pct to a 9/16-in. diam. Solid line: 4140 steel reduced 19.9 pct to a 11/16-in. diam.

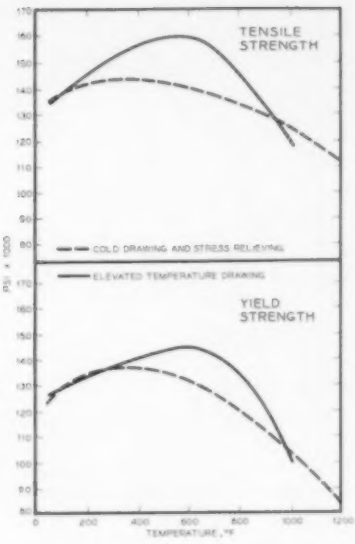


Fig. 8—A comparison of tensile and yield strengths obtained by cold-drawing and stress-relieving vs elevated temperature drawing.

temperature-drawn materials is similarly higher than the yield strength of cold-drawn and stress-relieved materials, although the difference between the two processes in this respect is not as pronounced. For example, the maximum yield strength achieved by stress relieving the cold-drawn bars of C-1144 was 138,000 psi. The yield strength achieved by elevated-temperature drawing in this instance was 146,000 psi. Elongation values are quite similar for both processes.

Since steels vary in composition, grain size, inclusion count, etc., from heat to heat even within a single AISI grade, the properties of cold drawn bars also vary. This variation can be compensated for to produce a more uniform product by adjusting the temperature of drawing. For example, if it is desirable to maintain the percent reduction and the grade, it is possible to change the tensile strength by approximately 25,000 psi by varying the drawing temperature.

Process visualized as an infinite number of deformation and aging steps

The tensile strength of cold drawn steel bars is only slightly affected by subsequent stress relieving treatments, while elevated temperature drawing may result in an appreciable gain in strength. This difference in properties cannot be associated with any obvious microstructural factors. The microstructures contain, in both cases, a mixture of ferrite and pearlite, carried over from the hot-rolled steel and are typical of cold-drawn C-1144 bars.

Evidently, simultaneous plastic flow and accelerated aging results in a greater strengthening of the crystal structure than can be produced by plastic flow followed by accelerated aging. However, it was thought that the process might be visualized as one where an infinite number of successive deformation and aging steps occur as the bar is plastically deformed during the drawing operation.

In an attempt to verify the above supposition, the following experiment was carried out. A 0.505 in. diam tensile specimen of hot rolled C-1018 was stretched 10 pct, then aged at 450°F for 30 min. A similar specimen was stretched a total of 10 pct in increments of 4, 3, and 3 pct. After each increment, the piece was aged at 450°F in the same way as the first tensile specimen. The ultimate tensile strength of the two materials was then determined.

The specimen stretched 10 pct and aged had an ultimate tensile strength of 68,500 psi. The incrementally stretched and aged specimen had an ultimate tensile strength of 73,200 psi. Thus, the multiple plastic flow and aging treatment resulted in an approximately 6.5 pct improvement in strength. Although this increase is not as great as that achieved by elevated-temperature drawing, it is in the right direction and lends some credence to the validity of this assumption.

Conclusions

These tests on elevated-temperature drawn bars clearly indicate the wide range of properties including high strengths which can be obtained. Bars produced by such processing have found applications where strength and uniformity are necessary and where machinability is an important economic consideration.

Heat treating with attendant processing steps (straightening, descaling, etc.) has been eliminated in the production of many parts by introduction of a medium-carbon steel bar (C-1144) produced by elevated-temperature drawing. This high-strength, free-machining steel has, for example, replaced: 1) 4140 heat treated to 29-35 R_c for milling machine spindles; 2) 4140 heat treated to 28-35 R_c for the main shaft of a power take-off unit; 3) 4340 heat treated to 30-34 R_c for a splined and threaded adapter unit; 4) C-1144 heat treated to 29-35 R_c for oil pump gears for diesel engines: and 5) 1045 heat treated to 35-45 R_c for a stub axle for farm equipment.

Conservation of expensive alloying elements and elimination of heat treating along with necessary subsequent processing steps are important advantages of this new process. Of economic importance also, is the development of a process which has wide flexibility thus permitting the production of a high-strength bar with uniform structure and quality.

References

[1] C. E. Sims and M. N. Landis: *Method of Producing Steel Products and Articles*, U.S. Patent 2,589,881, March, 1952, Assigned to LaSalle Steel Company.
[2] H. N. Landis: *Steel Product and Method of Manufacture Thereof*, U.S. Patent 2,320,040, May, 1943, Assigned to LaSalle Steel Company.
[3] A. Pomp and W. Knackstedt: *Mitt. K. W. Institut fur Eisenforschung*, vol. 10, 1928, pp. 117-174.
[4] A. Pomp and W. Lueg: ibid., vol. 15, 1933, pp. 81-97.

RADIOACTIVE TRACER STUDY OF STEEL SURFACE DEFECTS

At Algoma Steel, radioactive tracers have shown their value in establishing that some steel defects can originate in hot-top linings. The door has, thus, been opened for using this type of technique to trace other sources of non-metallic inclusions.

Summarized from an article by T. W. Crosta

WHEN killed steel billets undergo an upsetting operation prior to or during forging, extrusion, or other methods of fabrication, probably the most common surface defect that arises is the occurrence of splits parallel to the rolling direction of the billet.

Splits that may occur during the upsetting and forging of billets for bottles produced in the initial stages of the manufacture of some hollow shapes are illustrated in Fig. 1.

Origin of splits in upsetting

It had been believed that all splits on the bottles were due to the presence of seams on the billet before upsetting which had not been removed on conditioning the billet. Examination of a number of steel billets before and after upsetting indicated, however, that while crack-type seams did lead to splits on the bottles, in many cases short splits were produced from steel that appeared quite free from the usual type of seams. The incidence of these splits on bottles produced from direct-rolled billets was much higher than from double-converted billets, i.e. billets produced from previously conditioned blooms.

The origin of splits produced under such circumstances was not readily apparent; their occurrence appeared independent of factors related with heating before forging or with the upsetting process itself. Splits on killed steel occurred independent of the chemical composition of the steel, and they appeared to have no relation with the usual steelmaking practices that affect steel quality, such as pouring temperature, rolling temperature, etc.

A film of non-metallic matter

In the course of investigating this defect, a number of samples from split bottles were pulled apart transversely to the longitudinal axis of the split so that they fractured at the split. In the majority of specimens, a film of non-metallic matter was found adhering to the wall of the split near the base of the split. A number of specimens, cut adjacent to billet surfaces, were also pulled transversely to the rolling direction. With sporadic frequency, splits appeared in the fracture as a thin, grey, non-metallic film, generally lens shaped, and located just below, or tangent to, the billet surface. The size of the defects, after a 10 to 1 elongation of the ingot, approximated ¾ to 1½ in. long and ⅛ to 3/16 in. deep, Fig. 2.

In some cases actual small specks (pinhead to pencil lead size) of non-metallic matter were found and recovered in splits in bottles and billets in amounts sufficient for analysis. In general, the composition of the material was in the order of 56.0 pct SiO_2, 1.4 pct Al_2O_3, 1.0 pct MnO, and 33.0 pct Fe (mostly free Fe).

The composition of this non-metallic matter suggested that it might be of exogenous refractory origin. The thin grey scum could, however, only be approximated spectrographically and appeared to be principally aluminum with some silica present.

Relation between splits and slag condition

Generally, there appeared to be some relation between the incidence of splits in bottles and the degree of incidence of a particular condition found on billets as rolled. This condition is referred to at our plant as *slag*, and is also termed *sand, lime, or dirty steel* elsewhere.

Slag produces a white flash, or short split, in the cutting flame when the billet surface is being scarfed, and unless quite light, leaves a discontinuity in the scarfing cut. The condition rarely extends to a depth greater than ⅛ in. on billets, and can be removed with one or, at the most, two cuts of a scarfing torch, Fig. 3. Slag is often associated with seams, or, when exposed on the billet surface, may appear as a streaky, brown, refractory-like deposit, but, in many cases, there is no obvious indication of it on the surface.

Source: possibly hot-top lining

This slag condition on hot-topped steel became rather severe during a period when attempts were being made to increase the life of the refractory lining of the hot-tops by increasing the thickness of the material used to face the refractory lining. At this same time, the demand for hot-topped steel was high, which occasionally necessitated the use of poorly prepared hot-tops, and in some cases the linings were not properly dried. The hot-tops were of a composite type widely used in industry.

In view of these related facts, it was natural to suspect that the material used to face the hot-top lining might be the source of the slag condition. This

T. W. CROSTA is Process Control Metallurgist, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada. This paper is being presented at the 1958 National Open Hearth Steel Conference.

material is about 94 pct SiO_2 with an organic binder, widely used for the application referred to. It is rather friable after drying.

Initially, simple direct tests were made to establish whether a similar slag condition could be produced by the addition of a refractory material to the liquid steel. Material of the type used on hot-top linings was added to an ingot during pouring, and the billets from this ingot and one without this addition were examined. The steel without the addition was almost free from slag, while the four sides of the billets from the other ingot contained heavy concentrations of slag, closely resembling the defect under investigation.

Radioactive tracer studies commenced

Having established that slag could be derived from extraneous non-metallic material, it was decided to conduct a series of radioactive tracer studies to determine whether or not the hot-top lining was a major source of slag. At this point the services were engaged of Isotope Products, Ltd., a firm experienced in radioactive tracer techniques.

Hot-top lining materials are essentially siliceous in nature, but no suitable radioactive isotope of silicon is available to introduce into the test materials as a tracer, and, on the advice of the consultants, it was decided to use instead the radioactive isotope of lanthanum, lanthanum 140, in the form of lanthanum oxide—La_2O_3. Lanthanum 140 has a half-life of 40.5 hr and emits a 1.6 Mev gamma-ray with a half thickness of 1.5 in. in steel. The choice of radioactive lanthanum as a tracer was dictated, not only by the availability of a suitable isotope, but, by the relative chemical stabilities of lanthanum oxide, alumina, and silica at elevated temperatures.

At steel pouring temperatures (1800°K) the molar free energies of formation of lanthanum oxide, alumina, and silica in kilocalories per gram atom of oxygen are as follows, (based on Coughlin[1]): La_2O_3, 100.4; Al_2O_3, 87.5; and SiO_2, 66.7. Thus, this order of stability indicates that the deoxidizers normally used in steelmaking would not significantly disturb this oxide form of lanthanum when used as a tracer element. Another consideration favored choice of lanthanum 140, namely, that for all practical purposes, the radioactivity ceased after a period of two weeks, making the disposal of waste products relatively simple, while at the same time, a period of four days existed in which readily detectable levels of activity existed after removal of the lanthanum from the radioactive pile. If any silica that is intimately mixed with lanthanum oxide enters the liquid steel during the teeming of an ingot, and is retained in the solid steel near the surface of the ingot, the presence of this silica can be detected by the gamma activity of the accompanying lanthanum. This latter mechanism, at any rate, was proven out by the several tests to be described below.

Fig. 1—Splits occurring during the upsetting and forging of billets for bottles: bottom shows a typical non-seam type split, while upper bottle shows a split derived from a crack-type seam which was not properly removed from the billet.

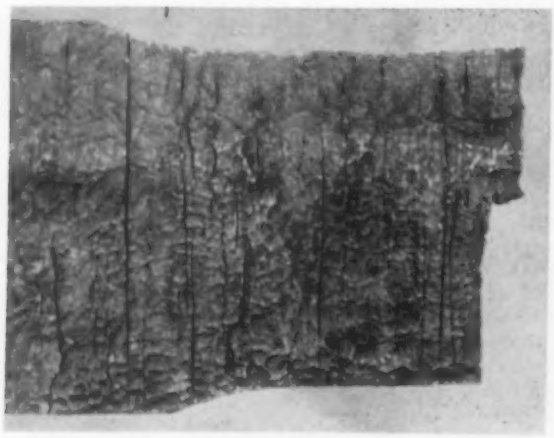


Fig. 2—Surface of a billet after elongation. Visible seams were exaggerated, and subsurface slag caused splits to open.

Radioactive lanthanum oxide

Finely powdered, radioactive lanthanum oxide was obtained from the atomic pile at Chalk River, Ontario, and was mixed by representatives of Isotope Products, Ltd., with the various refractory materials under investigation. For convenience, the

[1] Contributions to the Data on Theoretical Metallurgy, Bulletin 542, Bureau of Mines, James P. Coughlin, 1954.

Fig. 3—Slag leaves a discontinuity in the scarfing cut. It rarely extends to a depth greater than ⅛ in. and can be removed with one or two cuts of a scarfing torch.

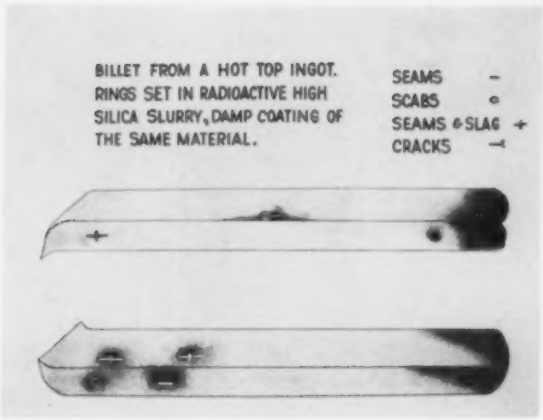

BILLET FROM A HOT TOP INGOT. RINGS SET IN RADIOACTIVE HIGH SILICA SLURRY, DAMP COATING OF THE SAME MATERIAL.
SEAMS –
SCABS o
SEAMS & SLAG +
CRACKS ≺

Fig. 4

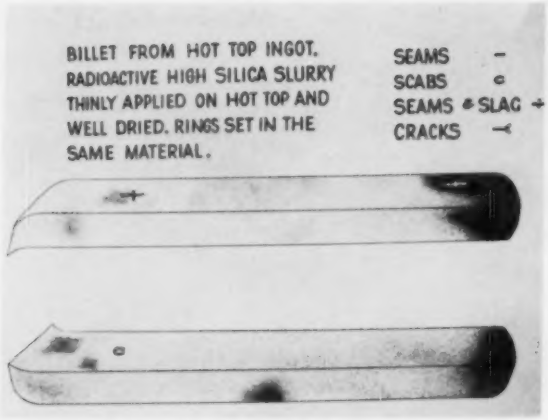

BILLET FROM HOT TOP INGOT. RADIOACTIVE HIGH SILICA SLURRY THINLY APPLIED ON HOT TOP AND WELL DRIED. RINGS SET IN THE SAME MATERIAL.
SEAMS –
SCABS o
SEAMS & SLAG +
CRACKS ≺

Fig. 5

materials containing the radioactive tracer will be described as being radioactive, although the expression in its strict sense is not true, since they were not intrinsically radioactive, but instead were intimately mixed with radioactive tracer.

In all heats, the grade of steel concerned was AISI 1012, fully-killed, fine-grained. The heat sizes were 100 tons. The nozzle size was 1¾ in., and pouring practice was good except where purposely modified.

The top-topped molds referred to were 27½ x 27½ in. big-end up, closed bottom, and the open-mold was 26 x 30 in. big-end down.

Stripping and rolling test ingots

After pouring, the heats concerned were left for 1 hr 30 min. before moving, and were then stripped. Four of the hot-topped ingots were charged into the soaking-pits immediately after stripping; they were then heated and rolled into 8½ x 8½ in. billets. The hot-top portions were cropped and kept separate from the billets. The billets were not machine scarfed.

It is known that when hot-tops of the composite type are removed from the ingot sinkhead, some of the hot-top lining material adheres to the steel sinkhead. The possibility was considered that some of this material might, during rolling, be transferred to other parts of the ingot. If this material were radioactive, it might offer serious interference with efforts to detect radioactivity from matter that had entered the steel during the pouring or solidification of the ingot. It was decided, therefore, to allow the other test ingots to cool to permit inspection before rolling. After examination, these ingots were reheated in the soaking-pits and rolled into 8½ x 8½ in. billets. The sinkhead portions of the hot-topped ingots were cropped off and kept separate from the billets, as was done with the top discards from the open-top steel. The billets were not machine scarfed.

Examination of the steel consisted of measurement of radioactivity on the surfaces by means of scanning with both a scintillometer and a geiger counter, by Isotope Products Ltd.; observations were also made of surface and sub-surface defects on the billets.

Results of tests

Figs. 4 through 9 show ingots and billets made from the casts into the ingot molds with radioactive coated hot-tops. The gradation in shading in the figures is intended to indicate the intensity of radioactivity, the heaviest shading being at the areas of highest activity. The symbols on the illustration are intended to denote areas where the largest number of defects were found.

Dampness of hot-top lining: Fig. 4 shows the billet from a hot-topped ingot; the hot-top lining was faced with radioactive, high-silica slurry, thinly applied, and the ring was set in the same material. The top was still damp when the ingot was poured.

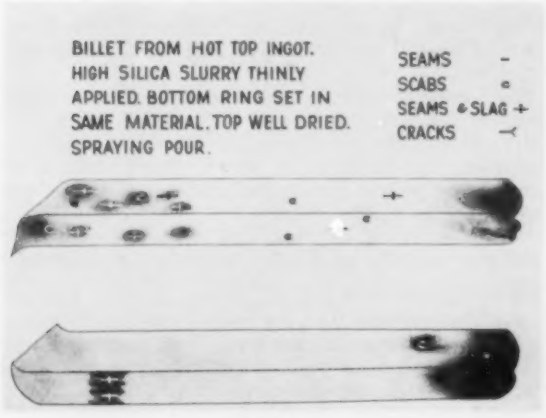

BILLET FROM HOT TOP INGOT. HIGH SILICA SLURRY THINLY APPLIED. BOTTOM RING SET IN SAME MATERIAL. TOP WELL DRIED. SPRAYING POUR.
SEAMS –
SCABS o
SEAMS & SLAG +
CRACKS ≺

Fig. 6

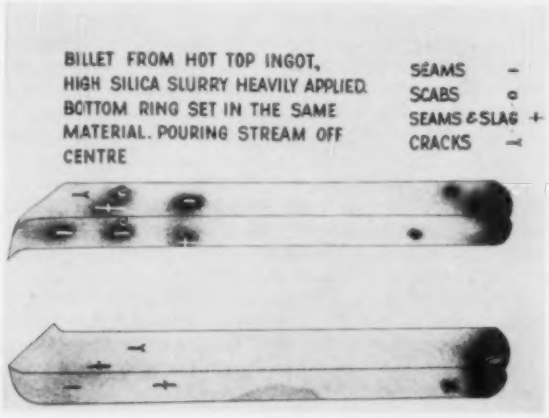

BILLET FROM HOT TOP INGOT, HIGH SILICA SLURRY HEAVILY APPLIED. BOTTOM RING SET IN THE SAME MATERIAL. POURING STREAM OFF CENTRE
SEAMS –
SCABS o
SEAMS & SLAG +
CRACKS ≺

Fig. 7

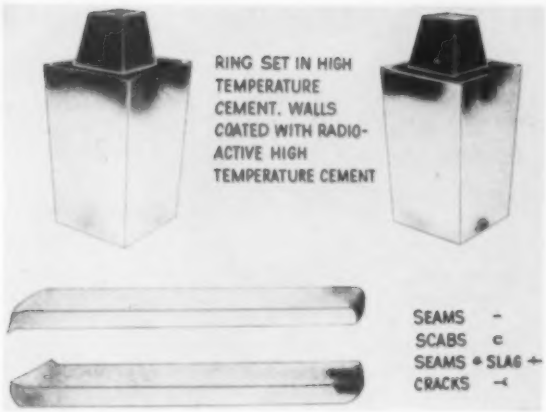

RING SET IN HIGH TEMPERATURE CEMENT. WALLS COATED WITH RADIO-ACTIVE HIGH TEMPERATURE CEMENT
SEAMS –
SCABS ○
SEAMS ◆ SLAG ⊣
CRACKS ⊣

Fig. 8

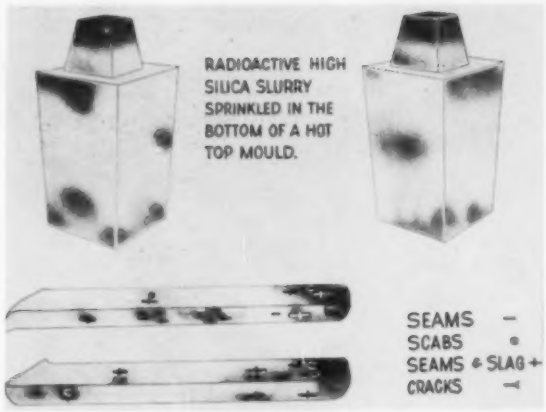


Fig. 9

The bottom of the billet, corresponding to the ingot bottom is on the right; it was highly radioactive. There were small areas of high levels of radioactivity near the middle and the top half of the billet, associated with seams, scabs, and slag. There was light to medium activity without visible defects elsewhere.

Fig. 5 shows the billet from a hot-topped ingot; the brick lining of the hot-top was faced with radioactive, high-silica slurry, thinly applied, and with the ring set in the same material. The top was thoroughly dried before the ingot was poured.

Relatively little radioactivity was found except for a few high areas near the top. A deposit of radioactive refractory was visible on one side—the bottom in the illustration. In other areas radioactivity was at a low level. The billet was almost free from visible surface defects.

Steel pouring technique: Fig. 6 shows the billet from a hot-topped ingot; the lining of the hot-top was faced with radio-active, high-silica slurry, thinly applied, and with the bottom ring set in the same material. The top was well dried. The ingot was poured with a spraying stream.

Numerous seams, scabs, and visible slag, usually associated with high levels of radioactivity, were found, mostly on the top halves of two adjacent sides.

Fig. 7 shows the billet from a hot-topped ingot. The lining was faced with radioactive, high-silica slurry, heavily applied, and the bottom ring set in the same material. The top was well dried. The pouring stream was held near one side of the hot-top.

Two adjacent sides—the upper two illustrated—showed areas of high uniform activity on the portions corresponding with the top half of the ingot; the activity was mostly associated with cracks, seams, and visible slag. Less radioactivity and a smaller number of defects was found on the other sides.

Alternate materials for hop-top lining: Fig. 8 shows a hot-topped ingot and the billet rolled from it. In this case the lining of the hot-top was faced with radioactive, high-temperature cement, and the ring was set in the same material.

Examination of the ingot showed radioactivity mainly confined to the sinkhead, the zone at and just below the shoulder, and the bottom of the ingot. A small number of inactive inclusions were seen on the surface. Radioactivity on the billet surfaces was at a very low level, and virtually no surface defects were present.

Refractory materials in mold bottom: Fig. 9 illustrates a hot-topped ingot and the billet rolled from it. The hot-top was prepared in conventional fashion, inactive, high-silica material being used to face the lining and to set the ring. Immediately before pouring, radioactive, dried, high-silica material of the type used on the hot-top was sprinkled on the mold bottom.

High levels of radioactivity were found on the ingot, particularly on the sinkhead and the ingot bottom. One cut with a handscarfing torch made no appreciable difference to the intensity of the radiation. Similarly, areas of intense activity were observed on the billet, and were associated with seams, scabs, and slag.

Summary of results

Refractory material in the steel that is derived from the high-silica slurry used to face the hot-top lining has a slight tendency to be concentrated near the top and bottom of the ingot. Material from the hot-top ring area is mainly confined to the upper portion of the ingot.

A damp coating of high-silica slurry on the hot-top lining, or a spraying pour, is conducive to the occurrence of hot-top material in the steel in appearance similar to the slag type defect.

High-temperature cement, used in place of the weaker-bonding, high-silica slurry in the hot-top, results in a much lower degree of contamination of the steel.

The high-silica hot-top material, if present on the mold bottom, as is sometimes found before pouring, generally appears in considerable amounts in the steel.

In numerous cases, radioactivity of a rather high degree was found at locations on billets where no surface defects were visible; on scarfing these areas, however, sub-surface slag was revealed. This condition, and typical surface defects are shown in Figs. 10 and 11.

Seams, scabs, and slag largely associated with radioactive material

Results showed that, in many cases, the seams, scabs, and slag found on the billets, were directly associated with the radioactive, non-metallic matter in the steel, because, when the defects were removed by scarfing, their accompanying radioactivity was either removed or substantially reduced. It

cannot be assumed, however, that seams, scabs, and slag were invariably associated with refractory inclusions derived from hot-top linings; examples of such defects without associated radioactivity were found on the billets being studied.

Conditioning for surface and sub-surface defects varied between light and moderate for the billets from the ingots with radioactive material on the hot-top lining. Where non-metallic matter was present on the mold bottom, it was necessary to effect complete surface removal of the billets to remove seams, scabs, and slag.

Transverse sections of the billets were taken from the tops and bottoms of each ingot and were examined with a radiation detector. Radioactivity appeared to be confined to the rolled surface of the steel.

Samples of scale taken from the ingots after heating in the soaking pits and immediately before rolling showed a high level of radioactivity.

It appears, then, that inclusions in the steel and derived from the hop-top lining or from refractory material at the bottom of the mold, tend to be entrapped near the surface of the ingot.

It is suggested that small pieces of the head-facing compound spall or wash off during the filling of a hot-topped mold, and some particles are swept by the convection currents along the mold walls, where they are trapped in, or just behind, the zone of chill-crystal formation as ingot solidification progresses. Refractories on a mold bottom may follow a similar path.

It is suggested also, that, at the time of their entrapment, the particles are generally associated with a gas bubble, which may be derived from contained moisture or combined water in the refractory or air entrainment.

These small voids may become lined with films of refractory deoxidation products during solidification, or a further possibility is, that during the soaking of the ingots in the pits before rolling, gas from the pit atmosphere diffuses into the cavity and reacts with deoxidizers to form a refractory film on the walls of the bubbles.

Upon rolling, the voids roll out to small surface or sub-surface defects that weld imperfectly due to their refractory film. The bubble may be associated with the refractory particle of its origin or have left it through agitation during teeming to be trapped separately. The above mechanics are offered as a tentative explanation.

Conclusions

Splits in billets undergoing upsetting may frequently occur at the point of incidence of a particular sub-surface defect which is usually associated with non-metallic matter entering the ingot during pouring. Seams and scabs on the billet may also sometimes be associated with non-metallic inclusions from the same source.

In the case of steel poured in molds with refractory-lined composite hot-tops, major sources of the non-metallic inclusions can be a high-silica slurry used on the hot-top lining and high-silica slurry particles not removed from the mold bottom. Conditions especially conducive to the entry of the hot-top refractory into the steel can be either an insufficiently dried hot-top lining or the pouring of the steel into the mold with a spraying stream.

A material with strong setting properties, such as high temperature cement, will give a lower incidence of steel defects than will a friable material on the face of the hot-top lining.

Fig. 10—Seams in the lower part of this photograph of the surface of a billet showed a radioactivity which registered 500 counts per minute on a Geiger counter compared with a background count of 200 per min.

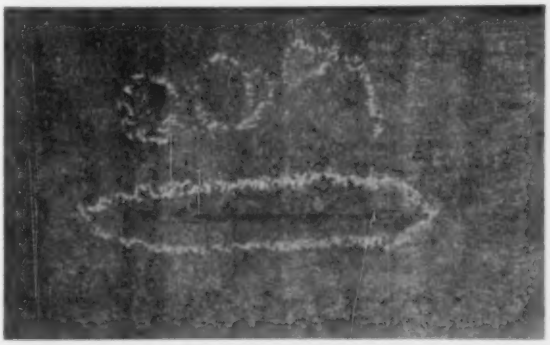


Fig. 11—Circled area shows slag visible on the surface of a billet. The Geiger counter gave 600 counts per min.

Non-metallic matter originating in hot-top linings, and refractory material on mold bottoms tends to be segregated near the ingot surface. When the ingot is rolled into billets, most of the material can be removed by removing the billet surface to a depth of ⅛ to 3/16 in.

It is evident from these findings that steel surface quality can be affected to a considerable degree by hot-top lining materials and their condition, and that hot-top preparation is worthy of close attention.

Hot-top lining practice modified

Algoma's hot-top lining practice has been modified to the extent that the lining is faced with a slurry of high-temperature cement. Total hot-top refractory costs have not been affected by the change in practice. Improvements have been made to hot-top drying facilities and hot-top preparation has been made subject to more exacting supervision. These measures have brought about an improvement in the quality of steels produced from hot-topped molds.

We believe that radioactive tracers have shown their value in establishing that some steel defects can originate in hot-top linings. It may be possible to use a similar technique to trace other sources of non-metallic inclusions, such as deoxidation products, ladle and furnace refractories.

CARBON MONOXIDE REDUCTION OF IRON ORE

New non-melting reduction process claims many advantages over previously reported sponge iron process; it is a continuous direct-reduction process making use of carbon monoxide in a fluidized bed. World rights to the new process are held by Stora Kopparbergs Bergslags A/B, Falun Sweden.

by Otto Stelling

CERTAIN attention is paid today to the weaknesses of the classical blast furnace process, and interest is continuously increasing in methods for direct reduction without melting. Several different methods have been developed or suggested in the past, but so far only a few have been adopted for practical use.

Another tendency in the iron industry of today is the change-over to concentrates, with an agglomeration as the first stage before reduction. It would mean a big step forward if this agglomeration process could be avoided, as it is often difficult to carry it out.

A practical solution of these two problems—direct reduction in a continuously operating process adapted to large scale production, and based on fine-grained raw materials without previous agglomeration, would certainly be of great importance. But due to the many difficulties of various kinds which arose when the sponge iron methods were brought into practical use, some skepticism is natural.

There are many reasons for the comparatively slow progress in the sponge iron field. One is the gangue content in the raw material, which naturally is also to be found in the sponge iron. However, with a still further concentration, this problem might not be too serious. Perhaps the biggest problem is to proceed far enough with the reduction without the material sticking to the furnace wall or sintering, both of which cause operational difficulties. The sticking can be avoided by decreasing the reduction temperature, but the speed of reaction is also diminished. The conditions would, however, be different, depending on whether hydrogen or carbon monoxide is used as a reducing agent. When using hydrogen, the reduction can be carried through at 500°C with suitable speeds of reaction, but with a very unsatisfactory utilization of the hydrogen. With carbon monoxide, there is spontaneous decomposition into carbon dioxide and carbon, and the speed of reaction is also lower compared to that obtained with hydrogen.[1] The further decomposition of carbon dioxide however, made it impossible to investigate the speed of reduction with carbon monoxide to temperatures below 800°C.

The fluidized bed, where a gas is pressed through a bed of fine-grained material with velocity so high that the solid particles make a turbulent movement, is characterized by a very intimate mixing of the solid material so that a constant temperature is acquired within the entire bed. Fluidization is reached at a certain linear gas velocity, determined by the physical properties of particles and gas, and occurs within a rather large speed interval. The particle size generally used in fluidized beds is 0.03 to 3 mm; the linear gas velocities generally range within 1 cm to 1 m per sec. The pressure fall in the gas stream corresponds roughly to the static pressure of the fluidized bed. Heat conduction of the fluid bed is very good; transmission from bed to wall is thus of the same magnitude as in a liquid. The small particle size and large surface between gas and solid phase contributes to the reaction speed.

At the end of the 1940's, the problem of treating hard-sintered ore in a fluidized bed was taken up. Another investigation contained many negative results from similar enquiries, and emphasized that such reduction would not be possible in commercial operation as, at a low degree of reduction, sticking of the particles *would* occur.

Investigations soon revealed difficulties of that kind do arise if one tries to carry out the process at normal thermodynamic temperatures. Tests were started at about 800°C, where the reduction is rapid, and particles began to stick at a comparatively low content of metallic iron in the bed. If the temperature was lowered to 725°C, reduction was only 60 pct and sticking of particles in the bed started. By exposing the bed to horizontal vibrations, the degree of reduction could be increased to about 70 pct, but sticking would again start. Additions of inactive material such as lime, coal, etc., had the same effect. A bed with a reduction degree of 70 pct can easily be kept fluidized at 725°C in a nitrogen atmosphere, but sticking immediately sets in if the nitrogen is replaced by carbon monoxide. Also of interest is that a bed of pure FeO shows very strong tendencies to stick at temperatures ranging from about 540° to 580°C, probably because below 570°C FeO is transformed into Fe_3O_4 and Fe. This transformation seems to be strikingly catalyzed by cementite. Beds of Fe_2O_3 and Fe_3O_4 show no tendency to stick below 900°C.

The first results obtained were thus not at all favorable for a technical adoption of this reduction method. Tests made at 700° showed, however, a diminished tendency to sintering. A closer investigation of the final product showed that the metallic iron had been transformed into iron carbide, probably according to the equation.

$$3Fe + 2CO \rightarrow Fe_3C + CO_2 .$$

It could thus be assumed that a bed consisting of iron carbide would not stick. If the process is carried out under such conditions that cementite and not metallic iron becomes the main product, sticking is avoided at temperatures up to 900°C.

Table I. Analysis of Concentrate Mixture

Fe_2O_3, pct	62.4	Al_2O_3, pct	0.9
FeO, pct	24.3	MnO, pct	0.7
Fe, pct	62.5	P_2O_5, pct	0.019
SiO_2, pct	5.6	S, pct	0.22
CaO, pct	1.8	Cu, pct	0.019
MgO, pct	1.8	Ignition loss, pct	2.1

OTTO STELLING is Professor of Metallurgy at the Royal Institute of Technology in Stockholm, Sweden.

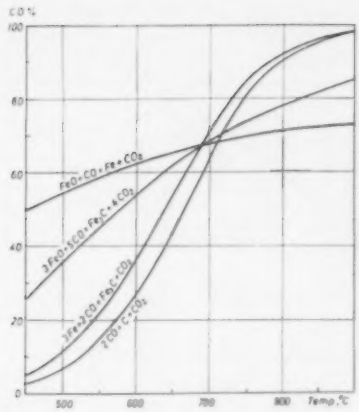


Fig. 1—Equilibrium constants calculated from thermodynamic data taken from U. S. Bureau of Mines Bulletin 476 and 477, and Chem. Eng. Handbook (1950).

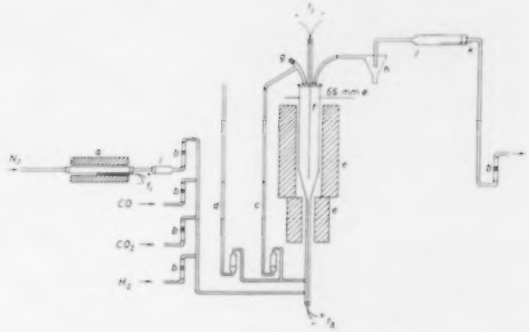


Fig. 2—Fluidized bed plant in laboratory scale: a) furnace, b) flow meter, c) manometer, d) manometer, e) furnaces, f) fluidization pipe, g) charging pipe, h) cyclone, j) dust collector, k) thermometer, and l) water absorber.

In order to define the conditions necessary for the reactions desired, we are going to deal with the equilibrium data for the reaction of FeO + CO. The reactions that can take place are the following

1) $3Fe_2O_3 + CO \rightleftarrows 2Fe_3O_4 + CO_2$
2) $Fe_3O_4 + CO \rightleftarrows 3FeO + CO_2$
3) $FeO + CO \rightleftarrows Fe + CO_2$
4) $3FeO + 5CO \rightleftarrows Fe_3C + 4CO_2$
5) $3Fe + 2CO \rightleftarrows Fe_3C + CO_2$
6) $FeO + Fe_3C \rightleftarrows 4Fe + CO$
7) $2CO \rightleftarrows C + CO_2$

Especially interesting are reactions 3, 4, 5, and 7. The equilibrium constants of these reactions, calculated in the usual way from thermodynamic data, are shown in Fig. 1, from which is seen that reaction No. 3, at temperatures above 710°C, leads to the stable state, i.e., that the final product that can be expected above 710°C is metallic iron. Below this temperature, reaction No. 7 is dominating from an equilibrium point of view, i.e., the carbon monoxide should in this case decompose into carbon and carbon dioxide instead of reacting with iron oxide. If, however, this decomposition of the carbon monoxide is disregarded, iron carbide ought to be the final stage below 690°C, either being formed by a reaction between FeO and CO or between primarily formed Fe and CO. A closer investigation of reaction No. 6 shows that FeO and Fe_3C, at a carbon monoxide pressure of 1 atm, can exist at temperatures of 710°C or lower, but not at higher temperatures, as the reaction will then result in the formation of metallic iron. At 600°C, the partial pressure of the carbon monoxide, at which this limit is to be found, is 0.14 atm.

A comparison of reactions No. 4 and No. 7 shows that at 600°C the partial pressure of the carbon monoxide at equilibrium is 50 pct according to reaction No. 4, but only 25 pct according to reaction No. 7. Results proved that the speed at which No. 4 was formed under prevailing conditions is much higher than for reaction No. 7. The difference in reaction speed is so great that the carbon monoxide seems to react completely, forming cementite, whereas the spontaneous decomposition cannot be verified. This is a most surprising statement, as general metallurgical experience indicates that, at temperatures just below 700°C, the reduction of iron ore, under ordinary conditions, cannot be carried through on account of the precipitation of carbon. Later tests have, however, verified this observation and promoted the development of the method now described.

Principles of the new method

In a fluidized bed with cementite as the main component traversed by carbon monoxide of relatively high concentration, concentrates are introduced at a temperature below 700°C. As the bed can be considered homogeneous, the same quantity of bed material, consisting of a product with a certain ratio between Fe_3C and FeO, according to the period of interruption, is removed. The free flowing product can be transported directly to an apparatus suitable for the treatment to follow, or, it can be taken out of the system after cooling to 300°C and stored. The product is then heated to 750°C or more, and a very rapid reaction takes place with subsequent sintering and formation of metallic iron.

The laboratory scale plant

Speeds of reaction were studied in a series of laboratory tests carried out in the apparatus described in Fig. 2. The fluidization pipe (f), made from 25 pct chromium steel had a diameter of 65.9 mm and was placed in an electric kiln. Reducing agent was carbon monoxide supplied from a gas tube after removal of iron carbonyl. Both in and outgoing gases were analyzed, as well as material taken from the bed.

In fluidized processes, a bottom limit for the gas velocity can be determined according to the following formula:

$$G_{mln} = \frac{g \cdot D_p^2 \cdot \theta^2 \cdot \rho_g (\rho_s - \rho_g) \cdot \Sigma^3}{180 \cdot \eta \cdot (1-\Sigma)} \text{ kg per sq m, sec}$$

where

G_{mln} = gas mass velocity in empty pipe (kg per sq m)
D_p = avg size of particles (m)
ρ_s = density of solid material (kg per cu m)
ρ_g = density of gas (kg per cu m)
η = dynamic viscosity of gas (kg per m s)
Σ = approximate pore volume—no dimension
g = 9.8 = earth acceleration (m per sq s)
θ = factor of particle form—no dimension

Estimates of the top velocity can be based on the limit value for beginning transportation of material of a certain size. This is how the region of gas velocity, in which the tests must be carried out, is determined. By means of the so-called J factors,[6] it is possible to estimate the influence of the gas diffusion on the process, or, in other words, to estimate the difference in the partial pressure of the carbon monoxide close to the reacting surface and in the

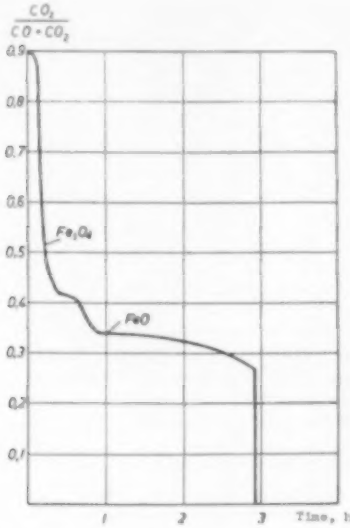


Fig. 3—Reduction of Orlinggruve concentrate at 600°C and gas flow of 2 liter CO per min, grain size <1 mm.

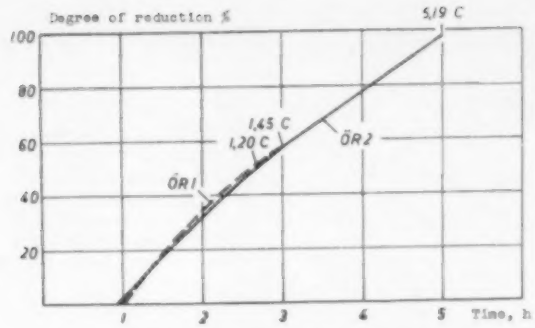


Fig. 4—Degree of reduction of the ore described in Fig. 3.

gas flow. The higher the gas velocity, the smaller is the difference. Based on values obtained as well as estimated, such a difference is calculated to $\Delta P = 3 \times 10^{-4}$ atm for the concentrate mentioned and at a gas speed of 2 litres per min. As the partial pressure of the carbon monoxide is about 1 atm, this difference of a millionth atm, is, of course, negligible. It is consequently possible to disregard the diffusion at these velocities when determining the equipment to be used. In the same way, it can be stated that the heat is transmitted quite satisfactorily so that the temperature of the mass particles can be considered equivalent to the average temperature measured.

Determination of reaction speed

The kiln was charged with about 400 g of concentrates (<1 mm) at room temperature, after which the bed was fluidized with pure nitrogen gas while the temperature was increased to the reduction temperature decided upon. When this had been reached, the nitrogen was substituted with carbon monoxide or a mixture of carbon monoxide and carbon dioxide. The values of in and outgoing gas were plotted as relative partial pressure of carbon dioxide vs time in Fig. 3. By estimating the surface below the curve at different lengths of time, it is possible to find the value of the degree of reduction, shown in Fig. 4. In order to control the process, the furnace was cooled at different intervals (under nitrogen) and samples were taken for X-ray investigations. The curves showing how the reduction degree is influenced by the time indicate, among other things, the good reproducibility of the tests. The shape of the curve in Fig. 3 reveals that the reaction is performed step by step. At first Fe_3O_4 forms rapidly, then slower forming FeO, and at last, very slow, the Fe_3C.*

* Here ought to be mentioned that at so high a temperature as 600° and at a long reaction time, a considerable formation also of the so-called Hägg Carbide has been discovered (See Z. Krist, vol. 89, 1934, pp. 92-94.

It may be interesting to compare the thermodynamic states of equilibrium at 600°C, calculated to be

Fe_2O_3/Fe_3O_4	100 pct CO_2
Fe_3O_4/FeO	56 pct CO_2
FeO/Fe_3C	46 pct CO_2

with the various steps. In a fluidized reactor, the solid phase has a constant composition, so all stages of reduction in the same charge are accomplished simultaneously. As the formation of Fe_3C takes place at the lowest speed, it is this that determines the total amount of reduced concentrates. In technical operation it is, of course, more advantageous to divide the process into several steps, and in that case to reduce to FeO in one step, which can be performed at a temperature of around 800°C and at an equilibrium concentration of about 70 pct CO_2. After this follows another step when reducing to carbide, the pressure of equilibrium then being 46 pct at 600°C. In this case the reaction

$$3FeO + 5CO \rightarrow Fe_3C + 4CO_2$$

will determine the speed. The problem is to determine the velocity in the latter process in order to make it possible to estimate the volume of the reactor.

The speed of reaction is usually expressed as

$$r = \frac{\text{amount of reacted FeO}}{(\text{total amount of FeO in bed}) \times (\text{time in minutes})}$$

The experiments so far have not aimed at finding an equation for the ratio between r and the different factors such as temperature, gas composition, etc., since this was determined with graphically established relations. Complications arise because material cannot be cooled down quickly enough. FeO is, as is known, not constant below 570°; it reacts, forming Fe_3O_4 and Fe. It is, therefore, necessary to make a correction of the established phase composition, corresponding to this decomposition. From the analyses made on the powder it can be seen that, at the beginning of the reaction, a certain content of metallic iron (5 to 10 pct) is at hand; the formation of carbide starts later. During the formation of carbide, the content of metallic iron is diminished, and the content of carbide is increased. As a consequence, it might be assumed that the reaction takes place in the following two stages:

$$3FeO + 3CO \rightarrow 3Fe + 3CO_2 \quad [1]$$

$$3Fe + 2CO \rightarrow Fe_3C + CO_2 \quad [2]$$

At low temperatures, the speed of [1] is so low that the reaction seems to continue directly into the carbide. At higher temperatures and in discontinuous operation, a certain amount of Fe can be found in the charge. Of even greater importance, however, is the discovery that the speed at which carbide is formed is of greater importance than the speed at which the carbon monoxide is decomposed into carbon and carbon dioxide. This seems to be the case in charges with a rather high metallic iron content as well as iron carbide. The spontaneous decomposition

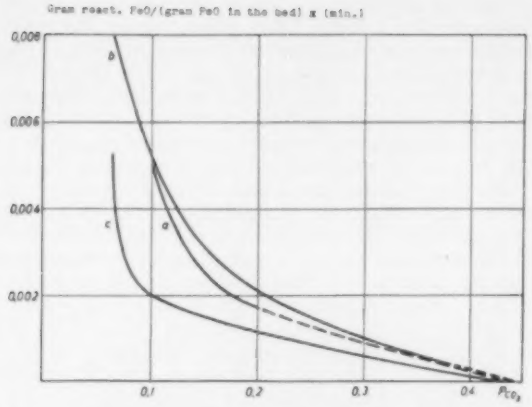


Fig. 5—Speed diagram for reaction (4) with a) Orlinggruve concentrate, b) pyrite cinders, and c) mixture of different concentrates.

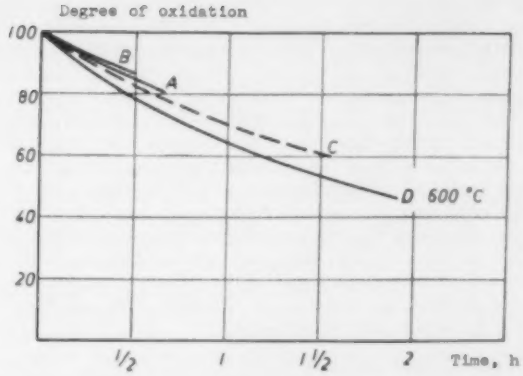


Fig. 6—Degree of oxidation where linear gas velocity equaled 1 cm per sec. A, hematite, and B, C, and D, different magnetite concentrates oxidized at 900°C with air; MgO content <10 pct.

of the carbon monoxide is apparently catalyzed by metallic iron, and the velocity seems to be at its maximum at temperatures around 600°C. In spite of that, the formation of carbide is more rapid at 600°C than the decomposition of carbon monoxide.

Preliminary oxidation important

As will be seen from below, there are some very compact magnetite ores where the reaction speed is so slow that the decomposition of carbon monoxide preponderates. If, however, an oxidation of magnetite to hematite is carried through first, the speed of reduction will increase to such an extent that these ores can also be reduced while forming carbide, without any decomposition of carbon monoxide.

The established speeds of reaction are dependent on the composition of the gas. An increase of the relative content of carbon dioxide will result in a decrease of the reduction speed, which should be 0 at the pressure of carbon dioxide that corresponds to equilibrium. The speed of reaction can thus be expressed

$$r = f/p_{CO_2}/ \qquad [3]$$

when assuming that $p_{CO} + p_{CO_2} = 1$.

The curve given in Fig. 5 represents the ratio between the reaction speed and the partial pressure of carbon dioxide in different concentrates. The quantity of reduced concentrate per unit time has been estimated for certain intervals and set in relation to the arithmetic medium for the partial pressure of carbon dioxide in the interval concerned.

As a result of the comparison of different concentrates, it appears that hematite concentrates, quite in accordance with earlier experience, are reduced much more rapidly than the magnetite concentrates. If, however, the latter undergo a previous oxidation, the speed of reduction for the oxidized product becomes normal again. This is clearly seen from Fig. 6.

In the use of magnetite concentrates it is, consequently, necessary to reoxidize the magnetite before reduction. In order to study this process, the oxidizability of various magnetite concentrates in a fluidized bed was watched at temperatures from 800° to 1000°C. It is quite possible to use the latter temperature without any tendency to sinter. It may be that still higher temperatures can be considered, but this question has not been investigated. The fluidization was carried through by air and the gas leaving was analyzed as to its content of oxygen. X-ray tests were made on the solid phase. On the basis of analyses obtained, the reacted amount of oxygen was calculated, and from that the degree of oxidation. It is found that with the Rudgruve and Smaltarmosse concentrates, the ratio of $\frac{Fe_3O_4}{Fe_2O_3}$ after 30 min of oxidation at 900°C amounted to about 0.4, whereas the corresponding value of Grangesberg concentrates after 20 min was 1.9, and even after 75 min, 1.2.

The technical method from which the experiments described above were made is similar to the Wiberg-Söderfors method as regards its general outlining. There are three separate phases of reaction, one oxidizing and preheating step, then a prereducing step down to around the wüstite stage, and finally a reducing step to finished product, which, in this method, however, is continued to cementite instead of to metallic iron as in the Wiberg-Söderfors process.

Possibility for continuous operation

The laboratory tests carried out did not, however, give any reliable idea of what possibilities were offered by this method for a continuous operation. It was not possible to entirely exclude the possibility that changes could occur in the bed at longer periods of reaction and, thus, create technical difficulties. On account of that, it was decided to erect a pilot plant calculated for a capacity of about 100 kg of reduced Fe per 24 hr at continuous operation. This plant is shown in Fig. 7. The reactor (A) consists of a cylindrical pipe of 25 pct chromium steel with an inside diameter of 355×2500 mm with a conic bottom measuring 450 mm in height, all material with a thickness of 5 mm. Although the process in itself is exothermic, the pipe is equipped with a Kanthal winding for supply of electric power. The whole of it is insulated and enclosed in a casing. The material is charged on to the bed from a silo (1) via a feeding screw (2) and the vertical pipe (3). The finished reaction product is discharged via the pipe (6) to a bed (7) equipped with a cooling mantle, where the material, still fluidized, is cooled and then discharged via pipes (12). For discharging, double cocks (13) are installed. The reducing gas is preheated in the electric preheater (I) and led out via the cyclone (5) to the heat exchanger (B) through the electrical dust separator (D), and the cooler (E) to the washing tower (F), where carbon dioxide

generated is washed away by water. The liberated gas passes the drying towers (G), the fan (H), and the heat exchanger (B) to the preheater (I) back to the furnace.

As was mentioned in the description, there was only one furnace section, whereas in general three different sections will be necessary. For that reason the process was carried through in two steps successively. The magnetite was first oxidized, then reduced to iron carbide in a later campaign. The first stages of the reduction process, the transformation of hematite to wüstite, are carried through so rapidly and without any difficulties whatsoever that this dividing of the process was not considered necessary in the pilot plant tests.

Pilot plant results

The results obtained from the tests were in complete correspondence with the laboratory tests. The reaction speeds, as well as the general behavior of the bed, were thus in complete accordance with expectations. By varying the time during which the material was kept in the bed, it was possible to control the final composition of the bed as far as the ratio between carbide and wüstite was concerned.

Best pilot plant tests were, for different reasons, carried out with a mixture of concentrates of a rather complicated composition, as shown in Table I. Oxidation was carried out at 900°C, as the experimental equipment did not allow any higher temperature. The content of ferrous iron was diminished to around 1 pct FeO within 40 hr. If the limit was fixed to 5 pct of FeO, the time of detention at 900°C would have been 14 hr, and at 1000°C, 3 to 4 hr. The yield of product discharged from the kiln was about 95 pct, while about 5 pct was found in dust collectors. The gas velocity used was about 0.166 m per sec. The counter-pressure in the apparatus at a charge of 390 kg, corresponding to a total height of the bed of about 2 m, amounted to about 5 m water column. The oxidation tests showed the same result as the laboratory tests. During oxidation, the sulfur content of the ore is decreased from 0.4 to 0.1 pct S. A higher temperature during the oxidation would probably cause a still higher removal of sulfur.

Two different reduction campaigns were made, one with carbon monoxide from a bottle, resulting in 85 pct CO and 5 pct CO_2 in the inserted gas; 60 pct and 30 pct respectively in the leaving gas. During the second period, a gas generated with charcoal was used, causing a lower total content of carbon monoxides, viz. around 65 pct CO and 2 pct CO_2 in the inserted gas, 50 pct CO and 20 pct CO_2 in the leaving gas. The contents of hydrogen in the gas generated with charcoal amounted to about 10 to 15 pct, and yet no disturbances arose in the process, whereas the content of nitrogen increased to about 15 pct.

Study of the results shows that the reduction obtained as regards the composition of the end products as well as the speed of reaction, are in excellent correspondence with the calculations based on the laboratory tests. The end products varied in content of Fe_3C between 60 and 90 pct with a total content of carbon of between 4.3 and 7 pct, out of which 0.1 to 0.2 pct consisted of free carbon and the remainder of carbide. The content of metallic iron is in general only a few percents, but an increase up to 10 or 14 pct does not cause any sticking. The time of reduction was, as expected, increased at higher contents of Fe_3C. The process can be driven to 100 pct Fe_3C without any noticeable difficulties. It seems, however, that in most cases it would be advisable to maintain a close equivalence between Fe_3C and FeO when continuing the reaction to metallic iron. When reducing extensively to Fe_3C, the material turns more and more brittle and tends to form more dust.

Hydrogen in reducing gas checked

When producing carbon monoxide on a technical scale or when carburizing carbon dioxide, there is always a certain amount of hydrogen formed in the reducing gas. It was to be expected that too high a content of hydrogen would facilitate the formation of metallic iron in the bed, with subsequent tendency to stick. The reaction

$$Fe_3C + 2H_2 \rightleftarrows 3Fe + CH_4$$

can take place, from a thermodynamic point of view, at a temperature of 600°C. The equilibrium conditions for this reaction are transferred to the right at decreasing temperature. The ratio between the partial pressures of methane and hydrogen at 550°C will thus be 1. As a consequence, it could be expected that, at a certain content of hydrogen in the reducing gas, a bed of iron carbide should be gradually transformed into metallic iron and sticking occur. The situation might also arise that wüstite is reduced into metallic iron more quickly by means of hydrogen than into carbide by carbon monoxide.

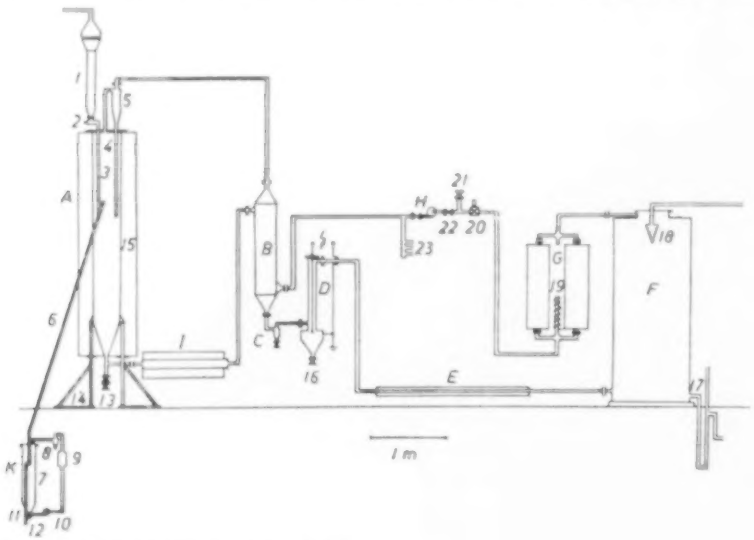


Fig. 7—Fluidized bed pilot plant for production of sponge iron. Reactor is a), heat exchanger b), electrical dust separator d), cooler e), washing tower f), drying tower g), fan h), and preheater i). Details of the plant are explained in the text.

However, experiments made as long-time tests on a pilot plant scale show that up to 30 pct H_2 may be used continuously without any disturbances of the fluidizing conditions. This statement is valuable inasmuch as that some day it may become desirable to use gas obtained by decomposition of oil or natural gas, in which case it will probably be necessary to maintain a not inconsiderable content of hydrogen.

Comparison with Wiberg-Soderfors method

The process can be carried out in different ways according to the requirements in each special case. In order to secure the most favorable heat economy, an adoption similar to the Wiberg-Söderfors method would probably be best. A comparison between flow of material and temperature in the two processes is shown in Fig. 8. The new method is here assumed to be carried out in three different steps: The concentrates are fed into an oxidizing room, where magnetite is oxidized to hematite at a temperature of about 900°C. After this, the material flows down to the prereduction zone, where it is reduced, at about 750°C, to the FeO stage. The material is then allowed to fall down into the final reduction zone, where the reduction is continued to carbide at 600°C. The material is then discharged via a cooler and can be tapped at about 200°C. The reducing gas, which is introduced into the final reduction zone at a relative content of carbon monoxide amounting to 96 pct CO and 4 pct CO_2, is divided in such a way after the final reduction stage that 82 pct is circulating through a carburettor, while the remaining 18 pct passes the prereduction zone and then the oxidizing zone, where the remaining CO is burnt. When leaving the final reduction zone, the gas consists of 65 pct CO and 35 pct CO_2.

Fig. 8 also indicates the temperature conditions; the gas coming from the carburettor must be cooled from about 1000°C down to about 300°C in order to secure equilibrium of temperature in the zone for final reduction. In the figure we have presumed preheating of the air to the oxidizing zone. On the whole, the two processes turn out to be equivalent as to consumption of material and power; the new method might have a somewhat lower consumption of coke. The consumption of electric power for the carburization may be somewhat lower than in the Wiberg-Söderfors process, but the fan work for the gas circulation will be a little higher.

A question that will not be dealt with in this article is the further treatment of the final product, which is highly rich in cementite. The product will, under all circumstances, become a valuable complement to ordinary sponge iron.

Conclusions and discussion

The main result of the experiments reported above can be summarized as follows:

1) In a fluidized bed of iron oxides reduced with carbon monoxide at high temperatures, disturbing tendencies to sticking will be found at a certain content of metallic iron.

2) If, however, the reduction is carried out at lower temperatures (around 600°C) in a fluidized bed under favorable conditions, cementite is formed instead of metallic iron, and the bed does not show any tendencies to sticking.

3) The forming of cementite takes place so quickly, under the conditions used, that the decomposition of the carbon monoxide into carbon and carbon dioxide does not set in.

4) The speeds of reduction for different hematite ores, as for oxidized magnetite ores, have been determined. Also the speed of oxidation for some magnetites was studied.

5) The features of a technical process based on the results gained has been described and studied on a pilot plant scale. The results were very promising. The method is operating entirely continuously and can, to judge from experiments with other fluidizing processes, be constructed in widely varying sizes. The capital requirements are relatively limited. A comparison with other methods will designate the process described here as the most advantageous in many respects. Risks for hanging of the material are entirely eliminated. The heat economy is at least equal to that of the Wiberg-Söderfors method. The cementite is resistant to air and does not show any pyrophoric properties. Cementite or cementite and wüstite as final product opens many prospects for the further treatment of the product. It can easily be incorporated in a fully continuous system.

6) In comparison with the H_2 reduction in a fluidized bed developed in the US, the above method presents many advantages. It is, for instance, operated at atmospheric pressure and without any cooling or heating cycles for the reducing gas. A production of hydrogen will normally be more complicated than producing carbon monoxide. It may not be impossible to use oil as well as natural gases for producing a suitable reducing gas.

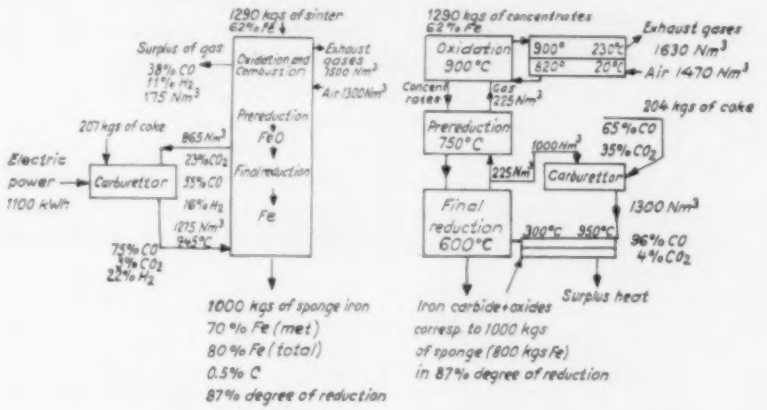


Fig. 8—A comparison between the Wiberg-Söderfors process and the carbon monoxide fluidizing proccess. U. S. Representative of the owners of the new process is Stora Kopparberg Corp., New York.

Walter R. Hibbard, Jr., President Metallurgical Society of AIME

Walter R. Hibbard, Jr., the second President of The Metallurgical Society AIME, is Manager of Alloy Studies Section, Metallurgy and Ceramics Research Department, General Electric Research Laboratory, Schenectady. Dr. Hibbard, the past chairman of IMD, was born in Bridgeport, Conn. He graduated from Wesleyan University in 1939 with a degree in physical chemistry, and received a doctorate in physical metallurgy from Yale University in 1942. After three years with the metallurgical section of the Bureau of Ships, USN, he returned to Yale, as an assistant professor, later becoming an associate professor. Dr. Hibbard joined the staff of General Electric's Research Laboratory in 1951, and was appointed assistant manager of the Materials and Process Section the following year. In 1953, he assumed his present post. He has been active in IMD since 1942, serving successively on the Programs Committee, the Mathewson Gold Medal Committee, the Publications Committee, and the Executive Committee. An author of more than 60 papers in the field of physical metallurgy, he has constantly endeavored to assure high standards in AIME technical publications. A 1950 recipient of the AIME Rossiter W. Raymond Award, he has been active in the Boy Scouts of America organization in Schenectady. Besides his membership in the AIME Board of Directors, Dr. Hibbard is also affiliated with the American Society for Metals; Institute of Metals (British); Yale Engineering Association; Registered Professor of Engineering, Conn.; Board of Directors of the Engineers' Joint Council; and the Electrochemical Society.

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AIME NEWS

Metallurgical Society Appoints T. D. Jones As New Treasurer

The appointment of T. D. Jones as Treasurer of The Metallurgical Society of AIME, was recently approved by the Board of Directors of The Metallurgical Society during the Annual Meeting.

Mr. Jones, a member of the Board of Directors of the Metallurgical Society, was born in Wales, Wisc. In 1922, he graduated from the University of Wisconsin, Madison, with a bachelor's degree in metallurgy. He later received his professional degree of metallurgical engineer from the same Alma Mater in 1929.

Since graduation from college, Jones has served with one company, American Smelting and Refining Co., commencing his association with the organization in August, 1922, at the Omaha, Neb., plant. His career with the company has been continuous, and at present, Mr. Jones is serving in the position of Chief Lead Refinery Metallurgist for the company's Barber, N. J. plant.

A member of AIME since 1931, he has for many years played a major role in the Extractive Metallurgy Division, and was Chairman in 1952. He has also served on the EMD Executive Committee, the all-Institute Admissions Committee, and the National Steering Committee.

T. D. JONES

The new Treasurer was one of six prominent graduates of the College of Engineering at the University of Wisconsin awarded a citation two years ago, for distinguished engineering services.

Journal of Metals

• The JOURNAL OF METALS is the first professional magazine for the metallurgist. It is published by The Metallurgical Society of the AIME and will include news of individual metallurgists throughout the world as well as their activities, particularly in the sections and divisions of the new Metallurgical Society. It is designed to provide information on metallurgical events of professional interest to scientists and engineers but to the metallurgist and to the metallurgical engineer, particularly. It will describe problems of metallurgical education and of the supply of professional manpower. The JOURNAL OF METALS will include articles describing new metallurgical plants and processes and be concerned with the problems and advances in the application and utilization of metals. It will also include summaries of new developments in the science, technology, and industry of metallurgy. It will include technical reviews and book reviews. It will include contributions from leaders of all aspects of the metallurgical profession. The JOURNAL OF METALS will take a worldwide view of metallurgy and will include descriptions of trends and advances in the rest of the world.

Transactions of The Metallurgical Society of AIME

• It is the policy of The Metallurgical Society to provide, in the TRANSACTIONS OF THE METALLURGICAL SOCIETY OF AIME, a prompt and accurate medium for publication of reports of significant new research in both the scientific and engineering aspects of metallurgy. Papers submitted to the Society are judged by competent reviewers according to established criteria for technical merit, accuracy, originality, and presentation.

High Temperature Conference in May

The AIME mining and metals branches together with the southern California chapters of the ASM will co-sponsor a four-day High Temperature Materials and Their Resources Conference together with a Molybdenum Fabrication Conference May 5 to 8, at the Ambassador Hotel, Los Angeles, Calif.

AIME general committee chairman R. H. Thielman, Stanford Research Institute, and ASM general committee chairman A. V. Levy, Marquardt Aircraft Co., have indicated that a comprehensive program of interest to professional engineers has been arranged.

Registration will start at 8 a.m. Monday, May 5th, at the Ambassador Hotel. The complete program is on p. 303.

Pioneer Bessemer Operator Dies

Toneson Braithwaite, 90, who devoted a lifetime to the production of steel, a role which saw him honored two years ago as the Nation's oldest living bessemer steel operator, passed away on Feb. 4, 1958 at his home in Knoxville, Pa.

Born in North Wales, a center of coal mining and steelmaking, Braithwaite came to America when he was twelve. He embarked on his pioneer career at fifteen when he was employed by the Bellaire Iron Co., Bellaire, Ohio. Three years later he joined Jones & Laughlin at the Pittsburgh works, where he aided in building the bottom on the plant's first converter and helped make the first blow in the relatively new process.

He served the company continuously as a blower for 44 years, converting countless thousands of tons of iron into bessemer steel. During all the long years of handling the bessemer converters with their 2000 degree molten steel, he never wore dark glasses and he lost only two weeks work during his entire career.

Mr. Braithwaite retired in 1930 after serving 47 years in the steel industry, nearly all of it with Jones & Laughlin.

The late Toneson Braithwaite, left, of Pittsburgh, shown in April 1956 receiving a momento as the oldest bessemer steel blower from AIME Bessemer Steel Committee Chairman, A. B. Wilder of National Tube.

In April 1956, he was the guest of honor of the Bessemer Steel Committee of AIME which met at the Lorain, Ohio works of National Tube Div., U. S. Steel Corp., to commemorate the One Hundredth Anniversary of the pneumatic converter process. The meeting climaxed a six month search for the oldest living bessemer steel maker in the United States. Braithwaite, was honored as the oldest in the U. S. and "possibly the oldest steelmaker in the world".

Definition of Engineering

The following definition of engineering has been suggested by the Recognition Committee of the Engineers' Council for Professional Development, 29 West 39th Street, New York 18, N.Y.:

> "Engineering is the Profession in which a knowledge of the mathematical and physical sciences gained by study, experience, and practice, is applied with judgement to develop ways to utilize, economically, the materials and forces of nature for the progressive well-being of mankind."

Any member wishing to comment on this matter should address such comments to *Mr. G. H. O'Sullivan, chairman of the Recognition Committee, ECPD, The J. G. White Engineering Corp., 80 Broad Street, New York 4, N.Y.*

Liege to be Scene of 31st Congress of Industrial Chemistry

Liège, Belgium, will be the seat of the 31st Congress of Industrial Chemistry from Sept. 7 to 20, 1958. This city was chosen as the scene of the Congress owing to the occasion of the Brussels International Exhibition. Metallurgy is on the program of the Congress as Group IV, and comprises two sections: Iron and Steel Metallurgy, and Nonferrous Metallurgy.

Officiating over the metallurgical section are: President, Marcel De Merre, director of Société Générale de Belgique, Brussels, Belgium; Vice Presidents, Prof. R. Breckpot, University of Louvain, Belgium; Prof. R. Meunier, Polytechnic Faculty of Mons, Belgium; and J. M. Quets, Consulting Engineer at Union Minère du Haut-Katanga, Brussels, Belgium.

President of the Iron and Steel Section is P. Coheur, professor at University of Liège, Belgium.

The Section of Nonferrous Metallurgy has as President J. Anten, Manager of Société Metallurgique de Prayon, Belgium. Vice Presidents are: Prof. C. Decroly, University of Brussels: Prof. E. Frenay, University of Liège, Belgium; and J. M. Quets, Consulting engineer at Union Minère du Haut-Katanga, Brussels, Belgium. Prof. R. de Strijcker, University of Louvain, is also serving on the committee.

Papers on metallurgy and ore dressing are invited. For these, the abstracts should reach the general office of the Congress before May 1, 1958.

GIANT WELDING SHOW

A mammoth welding exposition complete with plant tours, technical sessions, educational lectures, a practical welding conference, the annual meeting, awards and the largest welding exposition ever staged will bedazzle the week-long activities of the American Welding Society in St. Louis, during the week of April 14 to 18.

The exposition will feature the largest assemblidge of welding equipment and accessories ever gathered. Total exhibit space for this giant display, to be used by 125 companies, will cover 33,664 sq ft. This total tops the record breaking size in Philadelphia last year.

The show will run three days, April 15 to 17, at Kiel Auditorium, which is also the scene of the Welding Conference on April 15. At the annual banquet, Bennett Cerf, famed publisher, columnist, raconteur and television star of CBS's *What's My Line* will be the guest speaker. The annual banquet, to be held at the Hotel Statler, April 14, will follow the annual President's Reception which is the outstanding event of the Society.

The annual meeting will commence at the Hotel Statler on the morning of April 14, and will be followed by the delivery of the annual Adams Lecture. Ernest F. Nippes, of Rensselaer Polytechnic Institute, will present his paper on *The Weld-Heat Affected Zone.*

The technical sessions of the annual National Spring Meeting will present 63 papers of 95 authors, drawn from 15 states and Canada, in 21 sessions. The American Society of Mechanical Engineers' metals engineering division will co-sponsor four of the sessions.

Plant tours will include the A. O. Smith Corp. plant in Granite City, Ill., on April 16, where visitors will see for the first time the mass production assembly line of the all-welded 1958 Chevrolet automobile body frame. The following day, the tour will cover the Midwest Piping Co., a leading prefabricator of welded power plant piping and pipe fittings.

Earl R. Parker, of the University of California, will deliver the educational lectures on *Engineering Behavior of Welded Structures.*

Russian Literature Is Now Available

Engineers interested in Russian and east European technical material may be interested to learn that the Library of Congress has for the past several months issued monthly catalogs of literature accessions from these areas of the world. They are: *The Monthly List of Russian Accessions*, $12.00 yearly, and *The East European Accessions List*, $10.00 yearly.

These lists contain titles of publications received by the Library of Congress and a group of cooperating libraries. The title of each monograph and periodical is given in the original language and in English translation. Tables of contents of important periodicals are given in English translation. Also included in each list is a subject guide to the monographs and periodicals. Annual author indexes to the Russian monographs and East European periodicals are available.

Both lists may be obtained from the *Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.*

Arthur S. Flemming Award Winner

Don H. Barker, Jr., 33-year old supervisory metallurgist at the Bureau of Mines' Electrometallurgical Experiment Station, Boulder City, Nev., was the recipient of one of the ten *Arthur S. Flemming Awards* given annually to outstanding young men in the Federal Government. Baker, who is a member of AIME, was honored for his development of a fused-salt electrorefining process that already has made it possible to produce titanium metal in *super-pure* form and promises to be applicable to other metals such as zirconium, hafnium, chromium, and vanadium.

Development of the electrorefining process was one of several achievements for which Baker received recognition. According to the statement made by the Department of the Interior in nominating him for the Flemming Award, he displayed outstanding ingenuity and skill in devising and perfecting an improved arc-melting furnace which has attracted the interest of more than a score of major industrial firms. To the Bureau's knowledge, 11 companies already have built, for research purposes, electrorefining units patterned after the one Baker originated.

The awards, named for the former Director of the Office of Defense Mobilization who was also for many years a member of the U. S. Civil Service Commission, are sponsored by the Junior Chamber of Commerce of Washington, D. C., and the American Security and Trust Co. They bestowed the awards during a luncheon at the Nation's capitol on February 20.

New ISD Executive Committee Elected

The following officers were elected to the Executive Committee of the Eastern Section of the National Open Hearth Committee at a meeting of the Board of Directors held on January 23, at the Engineers Club in Philadelphia, Pa.

They are: *Chairman*, G. S. Baldwin, Standard Steel Works Div., Baldwin-Lima-Hamilton Corp.; *Vice Chairman*, C. B. Jenni, General Steel Castings Corp.; *Director*, H. A. Parker, Fairless Works, U. S. Steel Corp.; *Director*, J. C. Blythe, John A. Roebling's Sons Corp.; and *Secretary-Treasurer*, G. M. Hagenberger, Standard Steel Works Div., Baldwin-Lima-Hamilton Corp. R. Russel Fayles of Lukens Steel Co., Coatesville, Pa. was elected Chairman of the Program Committee.

To Hold Fall Meeting Of The Metallurgical Society in October

It was decided during the February 1958, AIME Annual Meeting, that the Institute of Metals Division Fall Meeting, scheduled each year in cooperation with the National Metal Congress, henceforth should be known as the Fall Meeting of The Metallurgical Society, sponsored by the Institute of Metals Division.

This year, for the first time, plans are being made for all three Divisions of the Metallurgical Society to participate in this meeting, which is scheduled for October 27-30, at the Carter Hotel, Cleveland, Ohio. Both the Extractive Metallurgy Division and the Iron and Steel Division plan sessions on Tuesday, October 28, which is also the date for the Annual Fellowship Dinner. These sessions will consist of invited papers. Sessions are planned for all four days of the meeting by the Institute of Metals Division.

Abstracts for IMD Sessions

In accordance with the procedures adopted last year (see page 651, May, 1957, JOURNAL OF METALS) many of the IMD Sessions will consist of abstracts submitted for consideration to the IMD Programs Committe by the deadline date of July 15, 1958. The abstracts should be between 200 to 300 words, and should be submitted in three (3) copies to: *IMD Programs Committee, The Metallurgical Society of AIME, 29 West 39th Street, New York 18, N. Y.*

Further information on the Fall Meeting will appear in the coming issues of JOURNAL OF METALS.

Albert Victor Bleininger Award In March

Dr. Alexander Silverman, Professor Emeritus of Chemistry, University of Pittsburgh, has received the *1958 Albert Victor Bleininger Award*. The presentation of the medal and scroll, symbolizing the award, was made at the Eleventh Annual Award Dinner of the American Ceramic Society, held March 14, 1958 in the Terrace Room of the Penn-Sheraton Hotel, Pittsburgh.

The *Bleininger Award*, one of the highest honors for achievement in ceramics, has been given each year by the Pittsburgh Section of the American Ceramics Society.

Dr. Silverman is an international authority on the chemistry of glass, author of over 200 publications, and holder of 32 patents.

Belgian Iron and Steel Conference Program

The 1958 International Iron and Steel Conference on the subject of *New manufacturing methods used in iron and steel metallurgy*, will be held in Belgium at Liège, Luxemburg, Charleroi, and Brussels from June 18 to 28, 1958. A summary program of this two week conference is as follows:

Section I) Liège, Wednesday, June 18, to Saturday, June 21, 1958. Theme: *New Methods Of Making Steel.*

Section II) Luxemburg, Saturday, June 21 to Wednesday, June 25, 1958. Theme: *New Methods Of Pig Iron Production.*

Section III) Charleroi and Brussels, Thursday to Saturday, June 26 to 28, 1958.

a) Charleroi, (Thursday June 26 and Friday June 27.) Theme: *Continuous Casting of Steel.*

b) Brussels (Thursday, June 26 to Saturday, June 28.) Visit to the World Fair, and closing session.

The full program of the Iron and Steel Conference, with registration forms, was distributed during the month of February 1958. Those interested in these activities but not having received this program may obtain it, with any additional information, by writing direct to:

Secrétariat des Journées Internationales de Sidérurgie 1958 c/o Centre National de Recherches Métallurgiques, Abbaye du Val Benoit, Liège, Belgium.

Acid Converter and Basic Oxygen Steel Committee Meeting

April 30, 1958, marks the date of the Acid Converter and Basic Oxygen Steel Committee Meeting. The morning will be devoted to an inspection trip through Jones & Loughlin's Aliquippa Works, Basic Oxygen Steel Plant. The afternoon will feature a technical meeting, to be held in Pittsburgh at the Duquesne Club. The group will leave Pittsburgh at 8:30 a.m. for the plant trip by chartered bus, and return for lunch.

Reservations are required, by those planning to attend. Those requiring hotel accommodations should contact the hotels direct. The Penn-Sheraton Hotel and the Carlton House are the most convenient for the bus trip to Aliquippa.

1957 NACE Awards Presented

The annual banquet of the National Assn. of Corrosion Engineers, on Wednesday, March 19, in San Francisco, marked the scene of the 1957 NACE Awards presentations. The banquet was held during the NACE 14th Annual Conference and Exhibition, March 17 to 21, 1957.

The Willis Rodney Whitney Award was given to **T. P. Hoar,** lecturer in metallurgy, Cambridge University, England. At the same occasion, *The Frank Newman Speller Award* went to **Robert J. Kuhn,** for more than thirty years, corrosion engineer for New Orleans Public Service Inc., New Orleans. **Edward Schaschl** and **G. A. Marsh,** in the research and development laboratory of the Pure Oil Co., Crystal Lake, Ill., were the recipients of the *1957 Young Author Award of NACE.*

Dr. Hoar is a consultant on corrosion matters to several large industrial firms. His work includes a series of projects for the International Tin Research and Development Council on corrosion of steel, tin, and tinplate. He also worked during World War II for the British armed services and for industrial concerns on corrosion matters.

Mr. Kuhn has been occupied since his graduation from Tulane University in 1923 with the corrosion problems of New Orleans Public Service Inc. These involve underground gas, electric and water lines, telephone and telegraph cables, and other underground structures. He has also worked on stray current problems associated with the electric railway system in New Orleans.

Schaschl and Marsh are the recipients of the *Young Author Award* for their winning paper entitled *The Effect of Dissolved Oxygen on Corrosion of Steel and on Current Required for Cathodic Protection,* published in the April 1957 issue of *Corrosion.* The paper was considered most meritorious among 52 papers competing.

Five Departments Now In School of Mineral Sciences at Stanford

The School of Mineral Sciences, Stanford University, Stanford, Calif., was reorganized on Sept. 1, 1957. The school now consists of five departments: geology, geophysics, metallurgical engineering, mineral engineering, and petroleum engineering. In the past, the school did not have separate departments, and the administration of the school was carried out through two divisions: the division of geology, and the division of technology.

The decision to departmentalize the School was prompted by the desire to distribute the tasks of management more evenly. Formerly, much of the administration of the School was carried out by the dean, the associate dean, and the head of the technology division. Now, a great part of this work will be assumed by the chairmen of the new departments.

News of EDUCATION

► The Massachusetts Institute of Technology will present a special summer course in *Metal Cutting* from Tuesday, June 17, through Friday, June 27, during the 1958 summer session. This two-week program is intended for people who are working in industrial production and technical education and who wish to broaden their understanding of the mechanisms involved in metal cutting. Emphasis will be on the fundamentals of the topics covered, which include the following:

Structure and properties of metals; mechanics of cutting; metal cutting instrumentation; plastic flow of metals during cutting; friction and wear in cutting processes and the role of cutting fluids; surface finish and its measurement; tool wear and tool life criteria; temperatures associated with machining; principles of machining economics; the optimization of automatic screw machine performance; grinding of metals; and new machining developments.

The program will meet Mondays through Fridays, from 9 to 12 and 1:30 to 4:30. Morning sessions will be devoted to illustrated lectures, and afternoons of the first week will be occupied by laboratory exercises. During afternoons of the second week, informal round-table discussions of problems submitted by those attending the program are planned. All sessions will be held in the Metals Processing Laboratory.

Tuition for the program is $250, due and payable upon notification of admission. Academic credit is not offered.

► An undergraduate program has been organized in physical metallurgy and material science as an option in Northwestern University's science engineering program. The metallurgy department at Northwestern was organized in February 1954, with M. E. Fine as Chairman since 1955.

The early planning and organization was under the direction of Dr. D. H. Whitmore. This comparatively new department was charged with developing a research and graduate student activity in physical metallurgy. Besides its new undergraduate program in physical metallurgy and material science, the department is also contemplating a new course on the structure of non-crystalline solids.

In addition, there are active research programs in many phases of metallurgy and material science: sintering, creep and stress-rupture, radiation damage, plasticity of precipitation on hardened alloys, kinetics of precipitation, low-temperature calorimetry, brittle fracture, quench-aging pure metals, dislocation theory of plasticity, internal friction, density of imperfections, tempering of steels, strain-aging, oxidation, and small angle X-ray diffraction.

In addition to these courses, undergraduates are offered, 1) Principles of the Properties of Materials, and 2) a year's sequence in physical metallurgy.

The departments research equipment includes a General Electric XRD5 X-ray diffraction unit with spectrometer, Bausch and Lomb research model metallograph, Instron testing machine, equipment for melting and fabrication of alloys, Van de Graff generator for accelerating electrons, hot stage microscope, complete machine shop facilities, and specialized research equipment.

► The University of Michigan, Engineering Summer Conference Program is now offering intense courses designed to make available the instructional resources of the University of Michigan in areas where the special interests of industry or business and of the Uni-

(Continued on page 301)

versity staff make such courses feasible.

The program for 1958 enbraces 15 courses which include: *Technical Writing*, June 16 to 20, Fee $150.; *Automatic Control*, June 16 to 25, Fee $200.; *Applied Machinability*, June 16 to 27, Fee $225.; *Introductory Survey Of Operations Research And The Management Sciences*. June 16 to 27, Fee $225.; *Advances in Design And Operation Of Distillation And Absorption Equipment*, July 7 to 16, Fee $200.; and *Engineering Approach To Surface Damage*, July 14 to 19, Fee $150.

Detailed information about these courses and others not described here will be provided in later brochures which may be obtained from the *Engineering Summer Conference Office, 2038 East Engineering Building, Ann Arbor, Mich.*

Advance registration is required in all the courses and should be completed approximately two months in advance of the course. Applications, and general inquiries should be directed to the *Co-ordinator of Engineering Summer Conferences*, at the above address.

Nature of Soviet Challenge Topic At Northern Ohio, NOHC, Meeting

Joseph W. Spretnak, professor of metallurgy, Ohio State University, was the featured after-dinner speaker at the Annual Meeting of the **Northern Ohio Section, National Open Hearth Steel Committee, AIME.** Three-hundred thirty-four registrants attended the meeting held at Hotel Pick-Ohio, Youngstown, on Thursday, March 6. Dr. Spretnak's topic was *The Nature of the Soviet Challenge*. He was one of eleven American metallurgists who visited Russia, in October, 1957. Full coverage of the trip was given in March issue of JOURNAL OF METALS.

Dr. Spretnak stated that the Soviets are concentrating their efforts in these areas: basic heavy industries, war industries, crude oil production, atomic power, space travel, and the science, technology, and research necessary to back up these efforts. Education has made great advances, and it is aimed at mass training, rather than for the elite, on the theory that it is necessary to have literate, interested workers in order to run the new technology. But, in the opinion of Dr. Spretnak, this approach does not bring forth major break-throughs in basic science. The nature of the challenge from the Communists is long range and is being waged on intellectual, cultural, political, scientific, technological, and educational fronts. To meet this challenge, the West must return to an intellectual approach. University professors must once again train the young as their primary responsibility. Research, and it should be uncommitted, must be dedicated to the seeking of new knowledge. This was Dr. Spretnak's answer for meeting the *Soviet Challenge*.

The technical session was opened with a paper on *External Desulfurization of Hot Metal in a Rotary Reactor*, by R. H. Parsons, technical assistant to the general manager, Diamond Alkali Corp. Mr. Parsons described the pilot model, now on service. The objectives of the rotary reactor include the minimizing of temperature losses, the lessening of fumes, the providing of a more intimate contact between hot metal and the desulfurizing agent, and the carrying out of the desulfurizing reaction in a minimum time.

The second paper on *Vacuum Casting of Large Volume Castings* was presented by John N. Hornack, assistant director, steel processing, Applied Research Laboratory, United States Steel Corp. The original research project was carried out as part of a study on hydrogen content in steel. To prevent hydrogen embrittlement and flaking, it was found desirable to keep hydrogen content below 1.5 parts per million. Hence, the development of the vacuum casting process for large castings.

A pleasant mid-session interlude was the showing of the film, *Steel Valley*. This was introduced by J. E. Sowers of the public relations department, Sharon, Steel Corp.

James E. Smith, superintendent, open hearth, Warren District, Republic Steel Corp. described the *Use and Advantages of a Carbon Sub-Hearth*. The installation, made at Warren in 1956, increased the hearth area 33 pct without charges to the checkers and the flues. Mr. Smith outlined the operating performance of the furnace, compared with the balance of the shop, and listed the noticeable advantages of the sub-hearth. Bottom delays were reduced 60 pct. Pan temperatures were higher, averaging 430°F, as compared to 404°F with brick construction. Temperature changes were much less, for example after 7 hr, 12°F, in contrast to 75°F with the brick sub-hearth.

The concluding paper, *Ladle Manganese Feeders*, was presented by William Wood, assistant superintendent, open hearth, Campbell Works, Youngstown Sheet and Tube Co. Mr. Wood pointed out that ferromanganese can be added in one of three ways: 1) all in the ladle during tap; 2) part in the furnace, prior to tap, the balance in the ladle during the tap; or 3) all in the furnace prior to tap. Greatest efficiency from the ferromanganese, is obtained from ladle additions. For high manganese heats, such as for electric weld specifications, it was not possible to add all the manganese manually to the ladle. Through installation of an automatic feeder, considerable monetary savings have been realized, combined with increased quality of the steel. The automatic feeder, with a hopper storing 10,000 lb of ferromanganese, can feed at the rate of 4500 lb. per min. This rate can be closely controlled, varied with the speed of the tap.

Serving as Co-Chairman of the meeting were Robert P. Hill, superintendent, electric furnaces, Lowellville Works, Sharon Steel Corp., and Thomas A. Cleary, Jr., assistant superintendent, open hearth, Brier Hill Works, Youngstown Sheet and Tube Co. Edward Britt, open hearth superintendent, Campbell Works, Youngstown Sheet and Tube Co., was General Chairman of the meeting, and served as Toastmaster at the dinner. Edward J. Brandon assistant division superintendent, Steel Production, United States Steel Corp., Youngstown, is the new Chairman of the Northern Ohio Section of NOHC. Incoming Secretary is F. J. Herman, superintendent, bessemer department, United States Steel Corp., Youngstown.

A pleasant time between technical sessions and the dinner was provided by the social hour, made possible by the sponsorship of many suppliers to the steel industry.

Index to Scientific Journals Available

Articles that are appearing in JOURNAL OF METALS are being indexed by the Library of the U. S. Naval Research Laboratory, along with 510 other periodicals in related fields.

The primary subjects included in these indexes are solid state physics, nucleonics, radiation, optics, mechanics, astrophysics, radio, guided missiles, artificial satellites, and space travel.

The original index cards are to be reproduced in book form by offset printing, 21 cards per page, 10 in. by 14 in. The publication will be available to only those who subscribe in advance of printing, which will start in the third quarter of this year.

The publication is offered by *Micro-Photography Co., 97 Oliver St., Boston 10, Mass.*

AROUND THE SECTIONS

• The **Mineral Industry Group** became the third sub-group of the **Pittsburgh Section** on Jan. 16, 1958, following the Institute of Metals Group and the Petroleum Sub-Section. Another group, on Iron and Steel, meets informally and contemplates formation as a sub-group. Members chiefly interested in coal mining meet jointly with the Engineer's Society of Western Pennsylvania. The Pittsburgh Section, with about 1700 members (third in size) and with a large diversity of interests, decided that these different phases could be best served by breaking up into sub-groups.

The Mineral Industry Group embraces as its aims and activities coverage in the fields of extractive metallurgy, non-ferrous and industrial minerals, minerals beneficiation, mineral economics, geology, mining and other general topics of interest to the minerals industry.

Officers were nominated by C. L. McCabe and N. K. Flint, chairman and past chairman of the Pittsburgh Section, to head the newest sub-group. They are K. F. Peterson, honorary chairman; Herbert A. Franke, chairman; R. D. Thomson and J. V. Melvin, vice chairmen; R. E. Lund, secretary-treasurer; and C. H. Schweinsberg, extra member of the executive committee.

Dr. Dennis J. Carney, division superintendent, steel production, Duquesne Works, U.S. Steel, was the featured speaker at the January 16th meeting of the new sub-Section. He discussed *Observations on Russian Steel Industry, and Technical Education*. Last October, Carney was a member of a ten-man exchange team between New York University and the Moscow Steel Institute which spent three weeks examining the Russian Steel industry and observing its technical education system. Carney, a former Naval intelligence officer in World War II, who speaks Russian, was able to talk directly with workers and managers in the Soviet Union.

Russia has more than doubled her steel producing capacity in the past seven years (from 27 to 57 million tons) and has set its goal at 135 million ingot tons. Most of the Russian steel mills are built near sources of the iron ore, of which it has great reserves. Carney visited two steel mills with a capacity as large or nearly as large as our biggest steel producers where blast furnace and open hearth unit output exceed many of ours. The self-fluxing iron ore is very carefully graded and mixed as to quality before being roasted in Dwight-Lloyd sintering machines.

The one-hundred and sixteen members and guests attending the dinner-meeting held at the Gateway Plaza, also learned that there is intense competition to attend college, admission being available to only about 25 per cent of those desiring to go. Most of the Russian college students are paid while attending classes.

• A dinner-meeting was held by the **Connecticut Section** on January 28, at the University Club, Bridgeport, Conn. Dr. Eraldus Scala, Avco Manufacturing Corp., was the Section's guest speaker. He talked on *Missile Material Problems*, covering the choice of materials for missiles applications, with particular emphasis on current studies on the effects of high heating and fast loading rates on the yield strength and ultimate strength of metals and alloys.

• The **Philadelphia Section** recently honored Walter Burd, metallurgist for the Carpenter Steel Co., at a Section meeting in Philadelphia, for his paper, *The Effects of External Compressive Stresses on the Isothermal Decomposition of Austenite*.

The Section presented him with a medal, certificate, and cash award for the outstanding paper on metallurgy presented by a Drexal student.

• The **Chicago Section** met on February 5, at the Chicago Bar Association, Chicago, to hear the topic *Metallurgical Coke from Illinois Coke*, discussed by Dr. Hubert E. Risser, Mineral Economist for the Illinois Geological Survey. Dr. Risser's study of this matter was found to be of great interest to those in the coal industry as well as in the steel industry.

• At the March 20th meeting of the **Utah Section,** L. L. Newman, assistant chief coal technologist of the U.S. Bureau of Mines, in Washington, D.C., delivered an address on *Mechanization of the Soviet Peat Industry*. His talk was highlighted with a film taken during his mission to the Soviet Union.

• The *H-Iron Process* was the subject of the featured speaker at the January 20, meeting of the **Detroit Section,** held at the Rackham Building, Detroit. The guest speaker, Dr. A. M. Squires, director of process development, Hydrocarbon Research Inc., described the H-Iron Process for reduction of iron ores by hydrogen at high pressures and relatively low temperatures. He gave capital cost and operating cost estimates and his experience in the use of H-Iron in steelmaking, both in open hearth and electric furnaces. Squires also presented data on economics of the use of H-Iron in steelmaking, both for an area such as Texas where natural gas is relatively inexpensive, and also for a typical East Coast area where natural gas is much more expensive.

Grover J. Holt, AIME President, and also general manager, Ore Mining Dept., Cleveland-Cliffs Iron Co., Ishpeming, Mich., was also a guest speaker at this meeting. He briefly discussed AIME operations, aims, and responsibilities.

• The **Powder Metallurgy Group** of the **New York Section** met at the Brass Rail Restaurant, New York, on Dec. 11, 1957 to hear a talk on *Production of Nuts and Washers From Brass and Nickel-Silver Powders*. This discussion was given by Philip V. Tarr, general manager, Midwest Sintered Products Corp., Chicago. He explained that through powder metallurgy techniques, nuts and washers can be made more cheaply than by other methods.

The product can be molded faster than by screw machines. An additional advantage of the powder metallurgy technique is that scrap losses are kept to a minimum.

Steel Valley **is a new 18-min. documentary film available free from Schmidt Assoc. 342 Madison Ave., New York 17, N. Y., or Public Relations Dept., Sharon Steel Corp., Sharon, Pa. This narrative film depicts how the lighter, tougher, new super-alloy steels and reactive metals are made and used. The part television plays in the rolling of great ingots, and shots of the melting and processing of steel in Sharon's Pennsylvania and Ohio plants, are among the highlights of the film. Frank Blair, the well known NBC commentator, gives the narration.**

Dr. Hibbard to Address Two Sections in May

Dr. Walter R. Hibbard, Jr., President of The Metallurgical Society of AIME, will address the **AIME Southern Nevada Sub-Section** on Wednesday, May 7th. The subject of Dr. Hibbard's talk will be *Russian Metallurgy*. On May 8th, he will speak on *Alloy Developments* before the **Utah Section** in Salt Lake City.

Dr. Hibbard is manager, Alloy Studies, General Electric Co., Schenectady, New York. He was part of a group of American scientists who recently visited Russia.

AIME HIGH TEMPERATURE MATERIALS CONFERENCE

May 5 and 6, 1958, Ambassador Hotel, Los Angeles, California

MONDAY, MAY 5

8:30 a.m.-10:00 a.m.

Session I—Current Research

Chairman: J. M. Denney, Aeronutronic Systems Inc. and California Institute of Technology.

Mechanical Properties of Refractory Oxides: Roger Chang, Atomics International, North American Aviation.

High Temperature Strength and Creep in Graphite: Howard Martens, Jet Propulsion Lab, California Institute of Technology.

Strength and Low Temperature Creep: R. D. Chipman, Atomics International, North American Aviation.

10:00 a.m.-12:00 p.m.

Session II—Introduction

Metals and Mining Joint Session

Geology and Resources of Minerals of the High-Temperature Metals: R. M. Foose, Stanford Research Institute.

The Refractory Metals Tungsten, Molybdenum, Columbium, and Nickel: L. Yentema, Stanford Research Institute.

12:00 p.m.

Luncheon

The Free World Resources and Economics of the High-Temperature Metals: J. W. Vanderwilt, President, Colorado School of Mines.

2:00 p.m.—METALS SOCIETY

Session III—High-Temperature Environmental Problems

Chairman: F. E. Marble, California Institute of Technology. Co-Chairman: J. Waseman, Douglas Aircraft Company.

Thermodynamic High-Temperature Objectives.

Materials for Containment of High Temperature Reactions: A. V. Levy, Marquardt Aircraft.

High Temperature Material Limitations: N. N. Ault, Norton Company.

2:00 p.m.—MINING SOCIETY

Session IV—Geological Relationships Of High-Temperature Metals

Geochemistry of Rhenium: Michael Fleischer, U. S. Geological Survey.

The Riddle Nickel Project: Oregon: John K. Gustafson, M. A. Hanna Company.

Geology of the Searles Lake Deposits with Special Reference to Tungsten: D. E. Garrett and L. G. Carpenter, American Potash and Chemical Company.

Molybdenum: Stewart Wallace, American Metal Climax, Inc.

Tungsten: U. S. Geological Survey.

7:30 p.m.

Banquet

A Metallurgical and Philosophical Tour of Russia; A Report by Color Photography of the Highlights of a Recent Trip Behind the Ferrous Boundary: N. J. Grant, Massachusetts Institute of Technology.

TUESDAY, MAY 6

9:30 a.m.

Session V—Progress In High-Temperature Metallurgy

Chairman: N. E. Promisel, Bureau of Aeronautics, U. S. Navy.

Behavior of Ceramics at High Temperature: N. J. Grant, Massachusetts Institute of Technology.

High Temperature Structural Properties: L. D. Jaffee, Jet Propulsion Laboratory, California Institute of Technology.

Trends in Refractory Metals: J. J. Harwood, Office of Naval Research, U. S. Navy.

High Temperature Oxidation: E. M. Mahla, E. I. duPont de Nemours & Co.

Electron Gun Furnace: Charles Hunt, Stanford-Research Institute.

12:00 p.m.

Luncheon

High Temperature Sources in Research: G. M. Gianinni, President, Gianinni Research Laboratory.

2:00 p.m.

Session VI—Theory of High-Temperature Effects

Chairman: Pol Duwez, California Institute of Technology.

Mechanical Properties of Ceramics: E. R. Parker, University of California.

Strength of Refractory Metals: R. W. Guard, General Electric Co.

Slip and Pinning at High Temperature.

Physical Properties in the Non-Metallics: John Hove, Atomics International, North American Aviation.

HIGHLIGHTS OF THE ASM MOLYBDENUM CONFERENCE PROGRAM

May 7 and 8, 1958

Ambassador Hotel, Los Angeles, California

Wednesday Morning, May 7

Molybdenum as a Structural Material
The Development of Molybdenum Alloys
The Production and Quality of Molybdenum Mill Products

Wednesday Afternoon

Performance of Molybdenum Gas Turbine Components
The Forging of Molybdenum and Its Alloys
Forming Molybdenum Sheet
Development and Application of Protective Coatings for Molybdenum

Thursday Morning, May 8

Fusion Welding Molybdenum
Brazing Molybdenum
Ultrasonic Welding

(Continued on page 304)

Twelfth Annual

NEW ENGLAND REGIONAL CONFERENCE THE METALLURGICAL SOCIETY OF AIME

April 18 and 19, 1958

General Electric Research Laboratory
Schenectady, New York

Thermal Processing of Metals and Ceramics

Friday, April 18

9:00 a.m. Registration

9:30 a.m. **METALS SCIENCE SESSION** **Chairman:** R. M. Treco, Olin Mathieson Chemical Co.

Motion of Defects in Metals	C. E. Birchenall, Princeton University.
Motion of Interfaces	K. T. Aust, General Electric Research Laboratory.
Recrystallization	C. G. Dunn, General Electric Research Laboratory.
Preferred Orientation	J. L. Walter, General Electric Research Laboratory.

1:00 p.m. **LUNCH** **Dutch Treat Lunch** in Research Laboratory Cafeteria

2:00 p.m. **PLANT VISIT**
A tour through the Metals and Ceramics building of the Metallurgy and Ceramics Research Department will be held followed by a tour through the manufacturing facilities of the Large Steam Turbine and Generator Department in downtown Schenectady. Bus transportation will be provided both from the Research Laboratory and from the Hotel Van Curler. Busses will return to the hotel about 5:00 p.m.

5:30 p.m. **COCKTAIL AND SOCIAL HOUR** Hotel Van Curler, Schenectady

Toastmaster: J. H. Hollomon
Dinner will be served at 6:30 p.m. followed by a talk *Adventures In Meteorology* by Vincent J. Schaefer of The Munitalp Foundation, Greenwich, Conn.

Saturday, April 19

9:00 a.m. **METALS ENGINEERING SESSION** **Chairman:** L. R. Frazier, Metals Hydrides Inc.

Effect of Orientation Textures on Mechanical Properties	Speaker to be announced.
Effect of Orientation Textures on Magnetic Properties	H. C. Fiedler, General Electric Research Laboratory.
Structure Control of Ceramic Systems	J. E. Burke, General Electric Research Laboratory.
New Developments on Furnace Atmospheres	G. O. Underwood, and R. B. Gilliam, New England Metallurgical Corp.

12:00 noon **LUNCH**

Dutch Treat Lunch in Research Laboratory Cafeteria followed by the Annual Meeting of the Conference Committee—open to all members of the New England Regional Sections.

ASM Molybdenum Conference

(Continued from page 303)

Thursday Luncheon

Missile Structures and Power Plants
Nuclear Energy
Electronic Equipment
Chemical Processing Industry

Thursday Afternoon

Fabrication of Electronic Components
Protective Coating Systems for Molybdenum
Press Extrusion of Molybdenum Tubing
Machining of Molybdenum and Its Alloys

PERSONALS

T. E. Dancy, previously senior development engineer with Jones & Laughlin Steel Corp., Pittsburgh, in the research and development dept., was recently promoted to research supervisor in the research div.

R. A. Lubker, formerly with Armour Research Foundation, Chicago, has become director of research and development for Alan Wood Steel Co.

Paul R. Gouwens has joined the metals research staff of Armour Research Foundation of Illinois Institute of Technology, Chicago, as supervisor of the foundry and steelmaking section of the Foundation's metals research dept. He was previously chief metallurgist for the Fahralloy Co., Harvey, Ill.

Howard Duane Cox is now associated with Kennecott Copper Corp., Ray Mines Div., Ray, Ariz., effective June 14, 1958. He joined the metallurgical dept. of the division as a metallurgical engineer in the Hayden plant, immediately following the receipt of his master's degree in metallurgical engineering from Stanford University, Palo Alto, Calif.

Donald L. Katz, chiarman of the department of chemical and metallurgical engineering at the University of Michigan, was named 1958 vice president of the 16,000-member American Institute of Chemical Engineers.

Charles B. Gilpin, an engineer from Madison, Wisc., has joined the Bettis plant, atomic power research laboratory operated in Pittsburgh by Westinghouse Electric Corp., for the Atomic Energy Commission. Gilpin

(Continued on page 308)

Technical Conference on

Quality Requirements of Super-Duty Steels

Sponsored by Physical Chemistry of Steelmaking Committee, Iron and Steel Division, Institute of Metals Division, and Pittsburgh Section, AIME, The Metallurgical Society of American Institute of Mining, Metallurgical, and Petroleum Engineers

May 5-6, 1958, Penn-Sheraton Hotel, Pittsburgh, Pennsylvania

MONDAY, MAY 5

9:15 am-12:00 Noon

Session I—Environment of Uses and Required Properties

Co-Chairmen:
G. A. Roberts, Vanadium-Alloy Steel Company
R. B. Gunia, United States Steel Corporation

Super-Duty Steels and the Conference: G. A. Roberts, Vanadium Alloy Steel Company.

Aircraft Engines: M. E. Cieslicki, Wyman-Gordon Company.

Aircraft and Rocket Airframes: F. R. Kostoch, North American Aviation, Inc.

Commercial Reactor Grade Materials: R. C. Dalzell, United States Atomic Energy Commission.

2:00-4:45 pm

Session II—Relationship Between Composition, Structure, and Properties

Co-Chairmen:
E. R. Morgan, Jones & Laughlin Steel Corporation
J. H. Bechtold, Westinghouse Electric Corporation

Stainless Steels and Hot-Work Die Steels for High-Strength Applications: A. J. Lena and F. A. Malagari, Allegheny Ludlum Steel Corporation.

High-Temperature Alloys: J. W. Freeman, University of Michigan.

Radiation Damage in Ferrous Materials: D. E. Thomas, Westinghouse Electric Corporation.

Factors Affecting Fatigue and Ductility in Forgings: G. E. Dieter, D. L. MacLeary and J. T. Ransom, E. I. Dupont de Nemours and Company.

Non-Metallic Inclusions and Fatigue Under Very High Stress Conditions: H. Hubbell, The Fafnir Bearing Company.

TUESDAY, MAY 6

9:00 am-12:00 Noon

Session III—Air Melting Practices

Co-Chairmen:
B. R. Queneau, United States Steel Corporation
R. Lindsay, Crucible Steel Company of America

Analysis Control of 17-7 PH Stainless Steel: L. F. Weitzenkorn, Armco Steel Corporation.

Meeting Cleanliness Requirements: Bruce Shields, United States Steel Corporation.

Control of Segregation and Ingot Structures on Lower-Alloy Steels: J. G. Mravec, Timken Roller Bearing Company.

Hot Working of Super-Duty Alloys: H. Freeman and T. N. Kelley, Universal-Cyclops Steel Corporation.

2:00-4:45 pm

Session IV—Special Steelmaking Practices

Co-Chairmen:
J. F. Elliott, Massachusetts Institute of Technology
K. L. Fetters, Youngstown Sheet and Tube Company

Effect of Vacuum Stream Degassing on Properties of Forging Steels: M. A. Orehoski and J. N. Hornak, United States Steel Corporation.

Special Steelmaking Process—Vacuum Melting: A. M. Aksoy, Crucible Steel Company of America.

Vacuum Melting of Alloy Steels: B. F. Richardson, Utica Drop Forge Division, Kelsey Hayes Corporation.

Summary

Super-Duty Steel Quality, Present and Future: W. J. Harris, Jr., Materials Advisory Board, National Research Council, National Academy of Science.

Evening Program

for Monday, May 5

6:00 pm—Terrace Room
Social Hour

7:00 pm—Pittsburgh Room
Banquet

Toastmaster: George A. Roberts, Vice-President, Vanadium-Alloys Steel Company

Speaker: Park H. Martin, Executive Director, Allegheny Conference on Community Development

Technical Program Chairman:
John F. Elliott, Massachusetts Institute of Technology

General Arrangements Chairman:
C. Law McCabe, Carnegie Institute of Technology

Technical Program

THIRD ANNUAL REACTIVE METALS CONFERENCE

AIME Niagara Frontier Section

May 27, 28 and 29, 1958, Hotel Statler, Buffalo, New York

TUESDAY MORNING, MAY 27, 1958

Golden Ballroom

9:00 a.m. **Welcoming Address**
G. L. Cox, Chairman, Niagara Frontier Section, AIME

9:15 a.m. **Keynote Address**
D. J. McPherson, Armour Research Foundation of Illinois Institute of Technology.

TUESDAY MORNING, MAY 27, 1958

Golden Ballroom

Properties and Applications—Titanium Alloys

Co-Chairmen: L. A. Yerkovich, Cornell Aeronautical Laboratory, Inc.
E. L. Harmon, Electro Metallurgical Company, Division of Union Carbide Corporation

10:00 a.m. **Application and Service Experience of Titanium Alloys in Aircraft Power Plants,** D. J. West, Aircraft Gas Turbine Division, General Electric Company

10:30 a.m. **An Advanced Titanium Alloy for Service at Temperatures in Excess of 800°F.,** E. Bohanek and H. D. Kessler, Titanium Metals Corporation of America

11:00 a.m. **Design of Heat-Treatable Titanium Alloys,** A. J. Williams, Department of Mines and Technical Surveys, Mines Branch, Physical Metallurgy Division, Ottawa, Ontario

11:30 a.m. **The Relationship Between Constitution and Mechanical Properties in Titanium-Rich Binary Alloys of Titanium and Cobalt,** G. R. Purdy, R. Taggart, and J. Gordon Parr, University of Alberta, Department of Mining and Metallurgy

TUESDAY MORNING, MAY 27, 1958

Empire State-Los Angeles-Washington Rooms

Consolidation—Powder Techniques

Co-Chairmen: Loren W. Smith, Symington-Gould Corporation
George F. Kappelt, Bell Aircraft Corporation

10:00 a.m. **The Powder Metallurgy Preparation of Some Zirconium Alloys,** Henry H. Hausner, Consulting Engineer, New York City, and H. S. Kalish, Sylvania-Corning Nuclear Company.

10:30 a.m. **Slip Casting of Tungsten,** F. R. Charvat, Electro Metallurgical Company, Division of Union Carbide Corporation

11:00 a.m. **Slip Casting Metal Powders: Molybdenum,** P. D. S. St. Pierre, General Electric Company

11:30 a.m. **Fiber Reinforced Titanium Alloys,** E. Weber, A. D. Schwope, and R. W. Jech, Clevite Research Center, Division of Clevite Corporation

TUESDAY AFTERNOON, MAY 27, 1958

Golden Ballroom

Consolidation—Melting and Refining

Co-Chairmen: A. C. Haskell, Jr., Titanium Alloy Manufacturing Division, National Lead Company
Walter Trainor, Titanium Alloy Manufacturing Division, National Lead Company

2:00 p.m. **The Cooling of Cold Mold Arc Furnaces With Air,** M. M. Kirk and P. C. Magnusson, Bureau of Mines, United States Department of the Interior, Albany, Oregon

2:30 p.m. **Some Experiences with Reactive Metals Melted in High Vacuum,** David W. Levinson, Armour Research Foundation of Illinois Institute of Technology

3:00 p.m. **The Effect of Electron Gun Melting on the Composition of Reactive Metals and Their Alloys,** Charles d'A. Hunt, A. R. Miller, H. R. Smith, and C. W. Hanks, Temescal Metallurgical Corporation

3:30 p.m. **Casting of Uranium Alloys,** J. O. Davis, C. E. Crompton, and G. E. Wuller, National Lead Company of Ohio

4:00 p.m. **A Preliminary Study of the Equilibrium of Carbon and Oxygen in Columbium with Carbon Monoxide Above 1600°C,** M. E. Sibert and M. A. Steinberg, Horizons Incorporated

TUESDAY AFTERNOON, MAY 27, 1958

Empire State-Los Angeles-Washington Rooms

Physical Metallurgy—Temperature Effects

Co-Chairmen: R. L. Reddy, Electro Metallurgical Company, Division of Union Carbide Corporation
George Craig, Associate Professor, University of Toronto

2:00 p.m. **Recrystallization Behavior of Columbium,** R. T. Begley and L. L. France, Westinghouse Electric Corporation

2:30 p.m. **Recrystallization Behavior of Dispersion-Hardened Molybdenum-Base Alloys,** T. A. Prater, General Electric Company

3:00 p.m. **Recrystallization of Molybdenum—½% Titanium Alloy by Electrodeposited Chromium and Nickel,** Gordon D. Oxx, Jr., General Electric Company

3:30 p.m. **Investigation of the Brittle-Ductile Transition in Vanadium,** B. A. Loomis and O. N. Carlson, Iowa State College

4:00 p.m. **High Temperature Internal Friction of Tungsten,** R. H. Schnitzel, Westinghouse Electric Corporation

4:30 p.m. **Annealing of Point Defects in Tungsten,** R. C. Koo, Westinghouse Electric Corporation

WEDNESDAY MORNING, MAY 28, 1958

Golden Ballroom

Physical Metallurgy—Phase Relationships

Co-Chairmen: R. A. Perkins, Electro Metallurgical Company, Division of Union Carbide Corporation
J. H. Westbrook, General Electric Company

9:00 a.m. **The Vanadium-Tantalum and Vanadium-Chromium Alloy Systems,** O. N. Carlson, D. T. Eash, and A. L. Eustice, Iowa State College

9:30 a.m. **The Effect of Intermediate Holding Temperatures on the Transformation of Beta Titanium,** Paul A. Farrar and Harold Margolin, New York University

10:00 a.m. **A New Technique for the Study of Hydrogen in Exothermic Occluders,** Owen M. Katz and Earl A. Gulbransen, Westinghouse Electric Corporation

10:30 a.m. **Solubility and Structure of Carbide Phases in Tantalum and Columbium,** M. L. Pochon, C. R. McKinsey, R. A. Perkins, and W. D. Forgeng, Electro Metallurgical Company, Division of Union Carbide Corporation

11:00 a.m. **The Chlorination of Columbium Ores and Concentrates,** B. N. Chakravarti and A. T. Prince, Department of Mines and Technical Surveys, Mines Branch, Division of Mineral Dressing and Process Metallurgy, Ottawa, Canada

WEDNESDAY MORNING, MAY 28, 1958

Empire State-Los Angeles-Washington Rooms

Properties and Applications—Nuclear

Co-Chairmen: G. M. Butler, Jr., Carborundum Company
W. E. Kuhn, Carborundum Company

9:00 a.m. **The Selection of Reactive Materials for Aircraft Nuclear Power Plants,** A. E. Focke, General Electric Company

9:30 a.m. **Fabrication of Critical Assembly Components from Non-Reactor Grade and Scrap Zirconium and Zircaloy,** A. Levy, A. R. Kephart, and C. P. Matuszyk, General Electric Company

10:00 a.m. **Development of Vanadium Alloys for Reactor Applications: Part I, Evaluation,** Karl F. Smith, Argonne National Laboratory

10:30 a.m. **Development of Vanadium Alloys for Reactor Applications: Part II, Mechanical Properties,** R. J. Van Thyne, Armour Research Foundation of Illinois Institute of Technology

11:00 a.m. **The Mechanical Properties of Arc-Melted Kroll-Process Hafnium,** C. E. Armantrout and H. Kato, Bureau of Mines, United States Department of the Interior, Albany, Oregon

WEDNESDAY AFTERNOON, MAY 28, 1958

Golden Ballroom

Physical Metallurgy—Interstitial Effects

Co-Chairmen: A. U. Seybolt, General Electric Company
J. D. Roach, Titanium Alloy Manufacturing Division, National Lead Company

2:00 p.m. **The Effect of Various Heat Treating Salts on the Hydrogen Content of Uranium,** C. E. Polson, C. F. Hall, and A. E. Guay, National Lead Company of Ohio

2:30 p.m. **Nature and Properties of the Thin Oxide Films on Zirconium and Zircaloy-2,** Kenneth F. Andrew and Earl F. Gulbransen, Westinghouse Electric Corporation

3:00 p.m. **Effect of Hydrogen on Tensile and Impact Properties of Thorium,** David Peterson, Iowa State College

3:30 p.m. **The Oxidation of Columbium and Tantalum Base Alloys,** A. B. Michael, Fansteel Metallurgical Corporation

4:00 p.m. **The Acid Pickling of Titanium Alloys,** Howard B. Bomberger and Ernest E. Knapek, Rem-Cru Titanium Incorporated

WEDNESDAY AFTERNOON, MAY 28, 1958

Empire State-Los Angeles-Washington Rooms

Metal Processing and Fabrication

Co-Chairmen: Donald G. Sturges, Carborundum Company
W. R. Clough, Electro Metallurgical Company, Division of Union Carbide Corporation

2:00 p.m. **Tantalum for Electrolytic Capacitors,** L. H. Belz, Kawecki Chemical Company

2:30 p.m. **New Developments in the Fabrication of Hafnium Control Rods,** J. B. Giacobbe, Superior Tube Company, and D. N. Dunning, General Electric Company

3:00 p.m. **Fabrication and Properties of Rhenium,** J. H. Port, Chase Brass and Copper Company

3:30 p.m. **Extrusion and Drawing of Zirconium Tube,** A. I. Blank, Chase Brass and Copper Company

4:00 p.m. **Brazing of Zirconium and Its Alloys,** Harry Schwartzbart, Armour Research Foundation of Illinois Institute of Technology

WEDNESDAY NIGHT, MAY 28, 1958

8:00 p.m.—Golden Ballroom

Panel Discussion

Subject: *What We Need to Know About the Reactive Metals*

Moderator: Bruce Gonser, Battelle Memorial Institute

Panel: J. H. Bechtold, Westinghouse Electric Corporation
A. E. Focke, General Electric Company
Earl T. Hayes, Bureau of Mines, United States Department of the Interior
E. M. Mahla, E. I. du Pont de Nemours, Inc.
David Swan, Linde Company Division of Union Carbide Corporation

Personals

(Continued from page 304)

will do engineering and development work on the reactor prototype for an atomic powered aircraft carrier.

J. D. Dickerson has been appointed to the newly-created position of manager—steel production, with offices in Pittsburgh, for the Crucible Steel Co. of America, Pittsburgh. Previously he had been staff assistant to the vice president—operations, to whom he will continue to report. In his new capacity, Dickerson will be responsible for steel-production operations at Crucible's Midland Works, Midland, Pa.; Sanderson-Halcomb Works, Syracuse, N. Y.; Spaulding Works, Harrison, N. J.; and Park Works, Pittsburgh.

John E. Decker has been promoted to chief metallurgist of Green River Steel Corp., Owensboro, Ky., a subsidiary of Jessup Steel Co., Washington, Pa. Decker was previously a superintendent at Green River Steel.

John W. Buskie was recently elected as a vice president of Tennessee Products & Chemical Corp., Nashville, Tenn. Tennessee Products & Chemical is a division of the chemical, paint and metallurgical dept. of Merritt-Chapman & Scott Corp., New York, its parent company. Buskie formerly served the company as a vice president of Tenn-Tex Alloy & Chemical Corp., a subsidiary, and was an assistant vice president of Tennessee Products & Chemical.

Clyde Williams, formerly president of Battelle Memorial Institute, Columbus, Ohio, has announced the formation of a new company to assist board of directors and top management of industrial corporations with broad technical and business problems. The new firm, to be known as Clyde Williams and Co., will serve a wide range of industries in the United States and abroad, and will have its central operations at 50 West Gay Street, Columbus, Ohio. Dr. Williams will serve as president of the new firm.

Ward M. Troutman, Pittsburgh district sales manager for the General Refractories Co., has been named vice president of the company. His office will remain in Pittsburgh.

William J. Harris, Jr., formerly assistant to the director of the Battelle Memorial Institute, Columbus, Ohio, has been appointed executive director of the Materials Advisory Board of the Division of Engineering and Industrial Research, National Academy of Sciences—National Research Council, Washington, D. C. The Materials Advisory Board is a group of distinguished scientists and engineers appointed by the president of the Academy-Research Council to serve, upon request of government agencies, as consultants on the properties of materials. Dr. Harris succeeds the late Verne H. Schnee in this post in September, 1957.

Three new faculty members have been appointed at the Colorado School of Mines, Golden, Colo. **Charles M. Schull, Jr.,** has been appointed an assistant professor of chemistry. He replaces **Richard J. Pratt,** who left the Institution to enter private industry as a chemical engineer. Schull has worked both in education, as an instructor at the University of Tulsa, and in industry, as an engineer and metallurgist. **Maynard F. Ayler** has been appointed an instructor in mining. Prior to this undertaking, Ayler was operating his own consulting geologists business.

David A. Rowland, formerly a reservoir engineer with the Tidewater Oil Co., has been named an instructor in petroleum engineering.

C. E. Russell was recently appointed steel division plant manager of the Ambridge, Pa. plant of National Electric Products Co., Pittsburgh. Before joining National Electric, Russell served as vice president in charge of manufacturing for the J. B. Beaird Co. Inc., a division of American Machine and Foundry.

The American Manganese Steel Div. of American Brake Shoe Co., New York City, recently announced new vice presidential assignments for two members of its management team and the promotion of two others to assistant vice presidents. **Joseph L. Mullin,** former vice president of the division, was named executive vice president. **W. Frank Kelly,** previously assistant vice president, was appointed vice president of operations. **John F. Holtman,** formerly division works manager, was named assistant vice president of operations, and **William E. Crocombe, Jr.,** previously central sales manager, was appointed assistant vice president of sales.

Three new appointments were recently made by Loftus Engineering Corp., Pittsburgh. **Alfred Augstine** has been named director of engineering. He has been with the company since 1940. **Edward A. Siemon,** who has served Loftus since 1946, has been promoted to chief engineer. **C. R. Wilt, Jr.** was appointed assistant chief engineer. Wilt joined Loftus in 1951.

Lewis W. Berger, formerly research metallurgist for Metals Engineering Institute of the American Society for Metals, was recently appointed to the position of training supervisor.

George V. Smith was recently appointed as assistant director for metallurgical engineering in the School of Chemical and Metallurgical Engineering at Cornell University, Ithaca, N. Y. Prior to joining Cornell, Smith was a research metallurgist with U. S. Steel research laboratory at Kearny, N. J.

Anaconda Sales Co., a subsidiary of the Anaconda Co., New York, recently announced the following executive changes: **Herbert M. Weed** has been elected vice president. **W. E. Kennedy** and **Clarence Glass** have retired as vice presidents, and **John A. O'Brien** has retired as assistant secretary.

Three divisional vice presidents were recently appointed by Pacific Coast Borax Co., division of United States Borax & Chemical Corp., New York City. They are as follows: **L. L. Fusby** as vice president, production; **R. W. Hinchman** to vice president, production; and **M. H. Pickard** as vice president, market research and product development. Hinchman and Pickard are continuing to make their headquarters in New York, and Fusby is continuing at Los Angeles.

Robert A. Hard has joined the staff of the Metals Research Laboratories, the Electro Metallurgical Co., division of Union Carbide Corp., Niagara Falls, N. Y. He is serving the company in the minerals and chemical engineering group.

Henry P. Kirchner, previously associated with the Corning Glass Co., Corning, N. Y., is now employed in the materials dept., Cornell Aeronautical Laboratory Inc., Buffalo, N. Y.

Bernard J. McCauley has been named new projects representative at Vitro Corp. of America's West Orange, N. J. laboratory. An expert in radioactive waste disposal techniques, McCauley has served Vitro's Chemical and Research Dept. in West Orange since 1951.

Otto Zmeskal, Florida professor and research metallurgist for the Atomic Energy Commission, has been named Dean of the University of Toledo college of engineering, Toledo, Ohio.

James C. Kelly has been appointed to the post of development chemist for General Electric Co.'s new product development laboratory, Pittsfield, Mass. Prior to his new assignment, Kelly had served as a process engineer for General Electric.

Wilbur L. Kennicott, who has headed Kennametal Inc.'s Latrobe, Pa., engineering activities, was recently elected a vice president of the company.

Edward D. Burton has recently been named resident manager of the graphite plant being built at New

Castle-on-Tyne, England, by Anglo-Great-Lakes Corp. Ltd., a British firm affiliated with Great Lakes Carbon Corp. of New York City. He formerly was plant manager of Great Lakes Carbon Corp.'s Electrode Division plant at Niagara Falls, N. Y. Succeeding Burton as Niagara Falls plant manager is **Raymond C. Newman,** formerly chief engineer of the Electrode Division.

E. William Place was recently appointed manager of the missile products Div., Beckman & Whitley Inc., San Carlos, Calif. He was previously product manager for missile devices.

Banshi Dhar Panda of Cattack, India, was recently appointed an assistant technologist in U. S. Steel's Applied Research Laboratory, Monroeville, Pa. Panda has been assigned to research work with the silicon sheet section of the research center.

Robert T. Farrell, who has been associated with Fairmont Aluminum Co., Fairmont, W. Va., since 1947, a wholly owned subsidiary of Cerro de Pasco Corp., was recently elected as president and chief executive officer of the company. He succeeds **Lawrence M. Brile** who retired in February.

R. B. McCarthy, previously assistant chief engineer, steel mill division, for Surface Combustion Corp., Toledo, Ohio, was recently promoted to chief engineer of the steel mill division.

OBITUARIES

Karl F. Peterson, (Member 1938), died Feb. 8, 1958, at his home in Beaver, Pa. At the time of his passing, he was superintendent of the Sinter and Cadmium plants of Josephtown smelter, St. Joseph Lead Co. Mr. Peterson was born in Kansas City, Mo. in 1906. Graduating as a metallurgical engineer from the South Dakota School of Mines and Metallurgy in 1930, he immediately associated himself with the St. Joseph Lead Co., and assisted in the construction of Josephtown smelter. Shortly before start-up, Mr. Peterson was named chief chemist of Josephtown smelter, a post in which he served with distinction until 1937 when he assumed responsibility for starting up and supervising the new Cadmium plant. Co-incidentally, he accepted the superintendency of the Sinter plant. During his 20-year stewardship, Mr. Peterson contributed significantly both to metallurgy and to the leadership of these departments. With a record of getting results by leading rather than by driving, Mr. Peterson commanded an unusually high degree of loyalty from his people. It was characteristic that he should give unstintingly of himself in an unobstrusive manner. This sense of responsibility for the welfare of others carried over into community activities. Mr. Peterson was a member of Beaver Bourough Council for the past eight years, was a past Deacon and Trustee of the First Baptist Church of Rochester, Pa., and for the past 15 years had been personally active in the Boy Scouts. Perhaps Mr. Peterson's most valuable contribution to AIME was the organization in 1955 of the Minerals and Economics Committee of the Pittsburgh Section. In January, 1958, this activity matured into the Mineral Industry Group, and the Pittsburg Section paid tribute to Mr. Peterson by electing him Honorary Chairman of the group. In addition to AIME, Mr. Peterson for the past several years served the Air Pollution Control Association in various technical capacities.

MEMBERSHIP

Proposed for Membership
Metallurgical Society of AIME

Total AIME membership on Feb. 1, 1958 was 29,911; in addition 2,959 Student members were enrolled.

ADMISSIONS COMMITTEE

J. H. Scaff, Chairman; Alfred Bornemann; F. B. Foley; T. D. Jones; L. L. Seigle; J. M. Warde; H. K. Worke.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

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Charles R. Hill, Great Falls, Mont.
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Student to Member

John J. Moran, New York, N. Y.

NECROLOGY

Date Elected	Name	Date of Death
1903	James L. Bruce Legion of Honor	Feb. 6, 1958
1956	Leon L. Larche, Jr.	Dec. 30, 1957
1946	Mark C. Malamphy	Mar. 18, 1957
1940	Joseph V. Mather	May 15, 1957
1912	James D. Mooney	Sept. 21, 1957
1924	John J. Oberbillig	January 1958
1938	Karl F. Peterson	Feb. 8, 1958
1952	Frederick W. Seyfarth	Unknown

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COMING EVENTS

Apr. 14-16, AIME, 41st National Open Hearth Steel and Blast Furnace, Coke Oven, and Raw Materials Conference, Hotel Statler, Cleveland.

April 17-19, AIME Pacific Northwest Regional Conference, Spokane, Wash.

April 18, 19, 12th Annual New England Regional Conference, General Electric Research Laboratory, Schenectady, N. Y .

April 18-20, Third Annual Mining, Mineral, and Petroleum Conference of Alaska Section, University of Alaska.

April 23, AIME Niagara Frontier Section, joint meeting with local section, Canadian Institute of Mining and Metallurgical Engineers, Royal Connaught Hotel, Hamilton, Ontario.

April 30, AIME Acid Converter and Basic Oxygen Steel Committee Meeting, Pittsburgh.

May 5, 6, AIME, Conference on Properties of High-Strength Steel, Penn-Sheraton Hotel, Pittsburgh.

May 5, 6, AIME High-Temperature Materials Conference, Ambassador Hotel, Los Angeles.

May 7, AIME Southern Nevada Sub-Section. Speakers, Dr. Walter R. Hibbard, Jr., President, The Metallurgical Society of AIME.

May 8, AIME Utah Section, Salt Lake City. Speaker, Dr. Walter R. Hibbard, Jr., President, The Metallurgical Society of AIME.

May 9-11, AIME Uranium Section, Third Annual Uranium Symposium, Moab, Utah.

May 12-16, Southwestern Metal Exposition and Congress, State Fair Park, Dallas.

May 21, NOHC Detroit Section, Hotel Fort Shelby, Detroit.

May 27-29, AIME Third Reactive Metals Conference; host section: Niagara Frontier Section; Statler Hotel, Buffalo.

June 6, AIME NOHC Southern Ohio Section, golf outing, Summit Hills Country Club, Fort Mitchell, Ky.

June 22-29, American Society for Testing Materials, Annual Meeting and Exhibit, Hotel Statler, Boston.

Oct. 3, 4, AIME NOHC Southern Ohio Section, fall meeting, Deshler-Hilton Hotel, Columbus, Ohio.

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Grant, Jacoby Studios, Inc.

Bailey Co., Wm. M. — 218
Downing Industrial Adv., Inc.

Baker Co., The J. E. — 251
Adams Associates Inc.

Basic, Incorporated — *
The Griswold-Eshleman Co.

Bell Telephone Labs. — 217
N. W. Ayer & Son, Inc.

Buehler Ltd. — *
Kreicker & Meloan, Inc.

Carborundum Metals Co. Div.
Carborundum Co. — *
Comstock & Co.

Consolidated Electrodynamics Corp. — 239
Rochester Div.
Rumrill Co., Inc., The

Consolidated Reactive Metals Inc. — *
Kurtz Art Associates

Corhart Refractories Co. — 262
Doe-Anderson Adv. Agency

Davison Chemical Co. Div. — *
W. R. Grace & Co.
St. Georges & Keyes, Inc.

Detrick Co., M. H. — 255
Bachrodt, Newell, O'Kane and Gano Inc.

Didier-Werke AG — *
Carl Gabler Werbegesellschaft MBH

Electro Met. Div., Union Carbide Corp. — 228
J. M. Mathes, Inc.

Ferro Engineering Co. — *
C. A. Reece Ind. Publicity

Frankel Co., Inc. — 229
Denham & Co.

General Refractories Co. — 215
Lewis & Gilman, Inc.

Great Lakes Carbon Co. — *
Davis, Parsons & Strohmeier, Inc.

Harbison-Walker Refractories Co. — 227
Downing Industrial Adv. Inc.

Hevi Duty Electric Co. — *
Bert S. Gittins Adv., Inc.

Hutton Fabricating Mfg. Corp. — 231
Ashby Adv. Co.

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Waldie & Briggs, Inc.

International Nickel Co. — 240
Marschalk & Pratt

Kinney Mfg. Div. — *
The New York Air Brake Co.
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Lectromelt Furnace Co. — Third Cover
The Griswold-Eshleman Co.

Leitz, Inc., E. — 245
L. W. Frohlich and Company

Marshall Products Co. — 226
Weber, Geiger & Kalat, Inc.

Michigan Chemical Corp. — 230
Wesley Aves & Assoc.

Mohr & Sons, John — 222
Fred H. Ebersold, Inc.

Molybdenum Corp. of America — 219
Smith, Taylor & Jenkins, Inc.

Morgan Construction Co. — 233
Davis Press, Inc., The

National Carbon Co Div. — *
Union Carbide Corp.
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Ohio Ferro-Alloys Corp. — 259
Huffman and Co.

The New York Air Brake Co. — *
Humbert & Jones, Inc.

Philips Electronics, Inc. — 223
Anders Associates Adv.

Ramtite Co., The — 221
Marsteller, Rickard, Gebhardt and Reed, Inc.

Smidth & Co., F. L. — 220
The Stuart Co.

Stokes Corp., F. J. — 224, 225
The Aitkin-Kynett Co.

Swindell-Dressler Corp. — *
Downing Industrial Adv., Inc.

Taylor Sons Co., The Chas. — 237
The Keelor & Stites Co.

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Unitron Instrument Div.
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Div. of Kelsey Hayes Co.
Zimmer, Keller & Calvert, Inc.

Valley Mould & Iron Co. — 238

Walsh Refractories Corp. — 257
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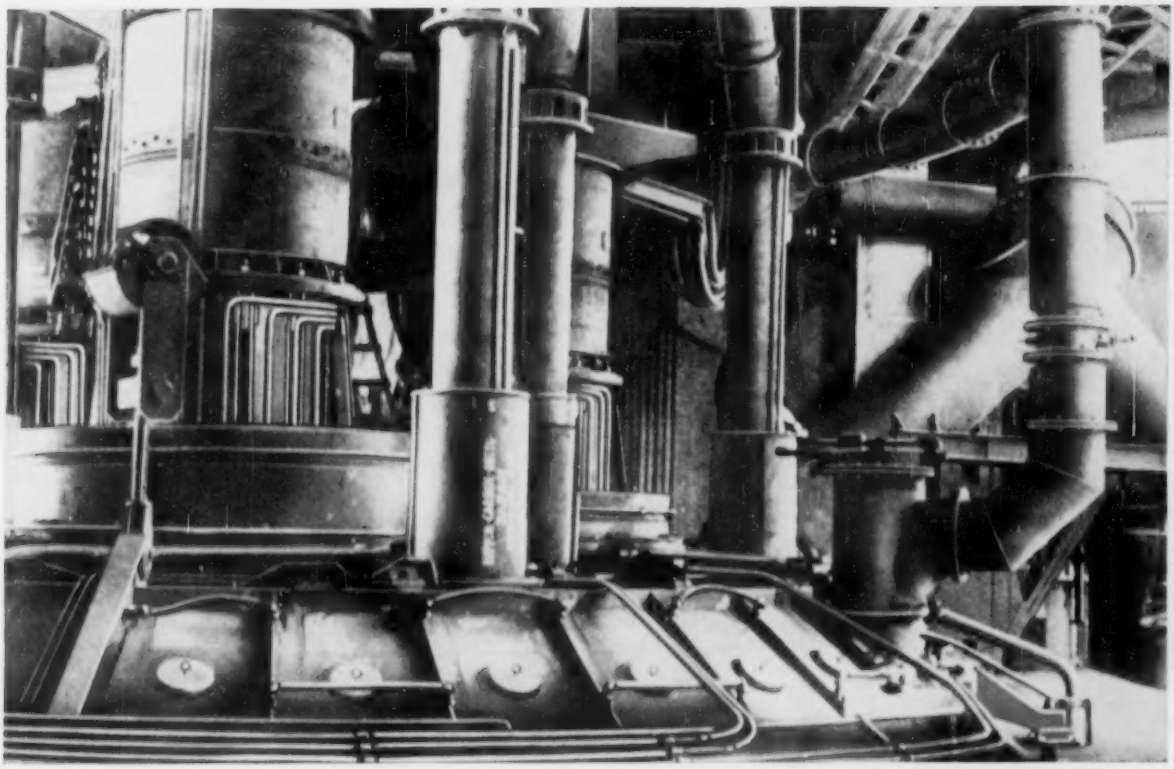

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